IT innovation theory and practice: a multi-case study investigation of organisational approaches and experiences in IT innovation.

by

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DECLARATION

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ABSTRACT

This thesis presents a multi-case study investigation of organisational approaches and experiences in information technology (IT) innovation. Building on an empirically grounded model of IT innovation based on these case studies, the research generates a knowledge framework that aims to enhance IT innovation theory and practice.

Innovation involving the production and/or use of IT has been shown to be important for economic growth. Organisation level studies suggest that IT enables innovation and that the probability of innovation increases with the intensity of IT use (OECD 2009). IT is inherently configurable and programmable and is routinely adapted and modified for use in a variety of applications across a range of domains. The general-purpose nature of IT provides significant opportunity for it to be directly involved in innovation activity (Brynjolfsson & Saunders 2010). Innovation involving either the application or production of IT is also very pervasive, extending beyond the IT producing sectors to most non-IT producing (IT user) sectors of the economy. But what is IT innovation? How is IT innovation achieved? How can IT innovation be analysed effectively?

There is already a considerable body of information systems literature on IT innovation, with much of it drawing on technology diffusion and technology adoption perspectives. While this body of work remains relevant, a number of problems have been identified including: (i) limited differentiation of IT innovation from IT development, implementation and evaluation processes; (ii) lack of insight into the different ways in which IT innovation occurs in practice and the factors important in any determination of IT innovation success and/or sustainability; (iii) prevalence of assumptions that IT innovation can be meaningfully conceptualised through a linear model of staged activities.

In contrast, recent theoretical insights from the broader innovation literature highlight the pervasiveness of innovation processes and the important role of collaboration amongst customers (users), competitors and suppliers operating within innovation systems. Innovation theory also emphasises the complex nature of innovation, the role of uncertainty and the emergent non-linear nature of technological developments that are themselves historically constrained and temporally situated.

Previous research has tried to examine how to resolve these contrasting perspectives on IT innovation and has endeavoured to combine macro-level perspectives of innovation theory with the micro-level understandings of IT innovation practice from the IT diffusion and adoption literature (Kwon & Zmud 1987; Mustonen-Ollila & Lyytinen 2003). For example – Swanson (1994) integrates perspectives from organisational innovation to map different types of IT innovation to organisational assets and capabilities; Lyytinen and Rose (2003) explore IT innovation in the context of disruptive innovation theory Christensen (1997) calls for a dynamic theory of IT innovation; and Wang and Ramiller (2009) emphasise the role of acquiring new, or modifying and reinforcing existing IT knowledge, through community interaction.

Whilst these insights at both macro- and micro-levels contribute to some understanding of IT innovation links to contemporary insights from innovation theory are less clear. These insights emphasise the importance of the objectives and effects of innovation, innovation activities, and linkages in the innovation process for facilitating the transfer and utilisation of knowledge and technology for innovation (OECD/Eurostat 2005). This multi-case study investigation aims to extend existing studies and incorporate broader elements of innovation theory to further consolidate understanding of IT innovation. The investigation obtained ethical approval from Tasmanian Health and Medical Human Research Ethics Committee (reference number H9949).

The methodology used in conducting this research adopted a research philosophy with a subjective ontology and interpretive epistemology. The research strategy deployed a multi-case study approach comprised of nine organisational case studies (Merriam 2014). Organisational cases were purposefully selected from organisations involved in the development, implementation and/or use of IT as part of self-reported IT innovation. A key objective in selecting cases was to maximise the opportunity to explore variation in approach and experience (Patton 2002) and as a result cases included organisations from both the IT producing and IT user sectors.

The case study research design involved data collection through semi-structured interviews in each organisation with key personnel who were closely involved with the IT innovation activity. Data was also collected and collated from available organisational documents related to the IT innovation. The researcher also collected field notes at each organisation to provide contextual support for subsequent case and cross-case analyses. Interviews were conducted using a semi-structured interview protocol designed to generate insights into the approaches, experiences and impacts of IT innovation. The protocol was structured into three main sections to explore the IT innovation based on the A-B-C heuristic model i.e. antecedents, behaviours and consequences (Brancheau & Brown 1993; Skinner 1938). All interviews were audio-recorded and transcribed within 24-36 hours of the conduct of each interview. In most organisations it was possible to subsequently contact and verify specific details generated during semi-structured interviews via telephone or a subsequent follow-up interview.

Data analysis was conducted in two stages. Stage one involved analysis of data from each individual case, organisational documents and field notes. Stage two involved cross-case analysis. During stage one, for each organisational case, interview transcripts were coded and analysed using an inductive (data driven) thematic approach broadly based on the recommendations in Miles & Huberman (1994), and deploying detailed analytical techniques as described in Braun & Clarke (2006) and Attride-Stirling (2001). Organisational documentation and field notes were utilised to assist in providing a context statement for each case and aiding understanding of the IT innovations investigated during interview. During stage two, emergent themes from each case were reviewed, compared and contrasted in an iterative process using the analytical approach advocated by Miles & Huberman (1994). Similarities and differences across cases were identified and organised using meta-matrices structured around related themes, social structures and information technology artefacts to categorise the diversity of approaches and experiences in IT innovation practices.

The results of this cross-case analysis were interpreted to produce an empirically grounded model of IT innovation. A key aspect of this model is its capacity to explain how regardless of initial motivation to commence IT innovation, the only investments in IT that subsequently evolve into genuine IT innovations appear to be those that are continuously and dynamically modified over time. Whether these modifications are formally planned or not, the key feature is that they evolve organically as a result of stimuli from within or external to the organisation, and that uncertainty and emergence are inherent properties of the benefits realisation. This enables the model to explain why in most of the cases analysed benefits from IT innovation generated were often unanticipated and/or exceeded initial expectations.

This model of IT innovation is used to structure the presentation of key findings from the multi-case investigation in the context of the primary research questions and research objectives. The key findings are as follows:

- IT innovation emerges from diverse sets of inter-relationships within and between individual and organisational decisions, activities and behaviours relating to information technology. It is intimately associated with the impact on organisational practices arising variously from the development and improvement of IT assets and capabilities. However, it is not causally linked to these practices relying rather on the capacity to leverage the knowledge and IT resources generated through these practices to achieve positive change.
- IT innovation is a complex, dynamic, and emergent phenomenon. Its outcomes are subject to uncertainty, often being unanticipated and/or exceeding original expectations. This fluidity relates directly to how decisions, activities, and behaviours iteratively evolve during the innovation process and how this influences the realisation of benefits. IT innovation is both an object of organisational investment and an agent of organisational change in a manner that tends to be non-linear, organic, and/or unpredictable.
- IT innovation occurs incrementally with the technology artefact being developed and continuously integrated, cycling through phases of IT innovation decision-making, IT innovation activity and IT innovation outcomes. The continuation of these cycles always being contingent on individual and organisational knowledge of the impact and benefit of these processes to that point in time.
- Decision-making in IT innovation is predominately influenced by either a motivation to solve problems associated with the collection, processing, storage and distribution of information, or a desire to exploit favourable or advantageous conditions created by developing new or enhancing existing information technology solutions. However, this decision-making is frequently impacted by difficulties associated with a number of factors. These factors include the capacity to identify and/or meaningfully evaluate the requirements for suitable IT solutions (new or existing) and the ability to respond appropriately to emergence arising variously from: (i) New problems and/or opportunities during development (ii) Competitive pressures, (iii) Dependencies

associated with technological advancements of co-dependent and complementary IT assets and/or human capabilities utilised in IT innovation.

- IT innovation appears to vary in subtle ways when comparing IT producers and IT users. IT producers often appear to take advantage of industry networks as source of knowledge and market access for IT innovation. IT users often partner with external developers or suppliers to source domain knowledge relating to IT engineering, development and implementation subsequently deployed in IT innovation.

Following presentation of the key findings embodied in the model of IT innovation they are discussed in the context of existing literature of relevance to IT innovation theory and practice. Based on this discussion the thesis generates a knowledge framework that extends the framework of Kwon and Zmud (1987) and integrating insights from contemporary innovation theory grounded in the multi-case analysis and findings. This knowledge framework moves beyond the limitations of diffusion and adoption perspectives previously employed by Kwon and Zmud (1987), Swanson (1994) and Mustonen-Ollila and Lyytinen (2003), and highlights the continuous and sustaining nature of IT innovation to encapsulate a knowledge framework that supports a dynamic model of IT innovation (Lyytinen & Rose 2003). The framework makes contribution at three levels substantive, methodological and conceptual.

At the substantive level the framework highlights the need to incorporate the dynamic and emergent dimensions of IT innovation. This research confirms the importance of mechanisms that combine domain knowledge with new and existing IT assets and capabilities to create platforms for continuous innovation. In particular, it acknowledges the role of requirements management and user feedback processes that can be used to improve the prospects of diffusion and derive extended and unanticipated benefits over longer time frames. Correspondingly this research also suggests that practitioners should be careful about having short-term views or objectives associated with realising the benefits of IT innovation.

For IT producers this research highlights the opportunity provided by third party IT platforms and their supporting ecosystems as sources of knowledge and market access for IT innovation. For IT users this research reveals the importance of interaction between users and developers to progress IT innovation. It also acknowledges the role of IT producers as an important source of IT domain knowledge for IT users.

At the methodological level the knowledge framework highlights that data collection and analysis must be sensitive to the dynamic and emergent aspects of IT innovation and needs to use tools and techniques contingent on the circumstances found in each case rather than on those features prescribed by theory. In particular, the knowledge framework highlights the need for researchers to recognise the tendency for IT innovations to be approached simultaneously as both objects of investment and agents of change transforming organisational processes. This research illustrates how data collection and analysis can explore the activities and events associated with the design, development and diffusion of IT innovations to reveal the continuous and incremental development processes; the role of IT assets and capabilities in IT innovation decisions, activities and outcomes over time; and the collaboration and interaction amongst stakeholders working on IT innovations within various diverse social and organisational settings. This involves being sensitive to the inherent dualism of technology (such that it is frequently approached as both and object and agent of change) in IT innovation to support identification of emergence and uncertainty in organisational settings.

At the conceptual level, it is anticipated that the model of IT innovation and knowledge framework combine to make a significant contribution to leveraging and grounding insights from innovation theory with the practices of engaging with IT innovation at the organisational level.

This thesis acknowledges that the model and framework have been generated from qualitative field techniques employed amongst a small number of organisational cases. Looking to the future, it is to be hoped that this model and the IT innovation framework will be tested in other IT innovation settings and further research findings contributed. It can be anticipated that with the increased use of “Big IT”, social media and increased consumer applications and services that researchers will need to extend the model and framework to deal with this diversity in IT innovation. However, it is anticipated that this thesis has contributed insights that will prove useful for both theory and practice in IT innovation

Keywords

Innovation, Information Technology, Information Systems

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1 INTRODUCTION

This thesis presents a multi-case study investigation of organisational approaches and experiences in information technology (IT) innovation. Building on an empirically grounded model of IT innovation based on cases of IT innovation practice, this research generates a knowledge framework that aims to enhance IT innovation theory and practice.

This chapter provides an introduction to the thesis, summarising the background and generating overview of the relevant theoretical domains, research problem, research objectives and research questions. This chapter is structured in the following sections:

- Section 1.1 presents the background to this research and the associated theoretical domains.
- Section 1.2 presents the research problem and outlines the research questions, objectives and scope.
- Section 1.3 provides a justification for this research and outlines the contribution of this research at the substantive, methodological and conceptual level.
- Section 1.4 outlines the subsequent chapters of this thesis.
- Section 1.5 provides a summary of this chapter.

1.1 Background to the research

Innovation involving the production and/or use of IT has been shown to be important for economic growth. Organisation level studies suggest that IT enables innovation and that the probability of innovation increases with the intensity of IT use (OECD 2010).

IT is inherently configurable and programmable, and is routinely adapted and modified for use in a variety of applications across a range of domains. The general-purpose nature of IT provides significant opportunity for it to be directly involved in innovation activity (Brynjolfsson & Saunders 2010). Innovation involving either the application or production of IT is also very pervasive, extending beyond the IT producing sectors into most non-IT producing (IT user) sectors of the economy (Smith 2002, 2005; Smith, O'Brien & Jerrim 2007). But what is IT innovation, how is IT innovation achieved, and how can IT innovation be analysed effectively?

The computer science and information systems literature (IT/IS literature) contain substantial theoretical and empirical knowledge concerning the development, implementation and use of information technology. This research highlights the organisational value of IT; the methods and techniques used for IT design, development and implementation; the sources of knowledge required and utilised for IT/IS implementation; and the system of industry structures, institutions and networks that facilitate IT/IS implementation. This research makes extensive use of diffusion and adoption based perspectives of innovation, with the occasional study looking towards organisational innovation theory for guidance. The IT/IS literature provides considerable insight into what IT innovation might be and what activities are involved (Fichman 2004).

In comparison to the IT/IS literature, innovation theory provides a broader range of complementary and contrasting views of innovation that may be relevant to understanding IT innovation. The innovation literature highlights the pervasiveness of innovation along with the role of collaboration amongst customers (users), competitors and suppliers operating within innovation systems (Ediquist 2005; Malerba 2002). However the innovation literature also emphasises the complex nature of innovation, the role of uncertainty (Nelson & Winter 1977) and the emergent non-linear nature of technological development (Kline & Rosenberg 1986), which is historically constrained and particularly dependent on the developments and decisions made in the past (Arrow 2000; David 1986).

This research is concerned with innovation that involves the development, adoption and/or use of IT. Central to this research is the concept of innovation and what is understood to be IT innovation, where the current understandings of IT innovation are subject to considerable ambiguity and heterogeneity.

1.2 The research problem

Over the last four decades organisations have invested heavily in IT. The IT/IS literature demonstrates that many researchers have looked at the IT investment process in an attempt to understand the factors that will support and facilitate investment in IT. However IT continues to evolve at rapid rate and there are incomplete understandings. This includes a high degree of uncertainty about the combination of factors and inter-relationships that really help to deliver success (Kohli & Grover 2008).

When firms deliberately choose to invest in IT for innovative purposes, as opposed to operational purposes, they consciously view themselves as making some kind of investment to provide them with a strategic or competitive advantage.

The existing IT/IS literature has a number of approaches for looking at the issues. The IT/IS literature is dominated by innovation diffusion and adoption based perspectives, but this is recognised as being somewhat fragmented (Lucas, Swanson & Zmud 2008). Conventional diffusion based models tend to rely on overly simplistic definitions of what IT innovation is, how it occurs, and what factors are critical to its success and/or sustainability. While this body of work remains relevant, a number of key problems have been identified including: (i) limited differentiation of IT innovation from IT development, implementation and evaluation processes; (ii) lack of insight into the different ways in which IT innovation occurs in practice and the factors important in any determination of IT innovation success and/or sustainability; (iii) prevalence of assumptions that IT innovation can be meaningfully conceptualised through a linear model of staged activities. As a consequence the IT/IS literature does not appear to capture the range of factors often identified within innovation theory. Rarely is IT innovation differentiated clearly from IT development, implementation and use. There are often implicit assumptions that IT innovations are easily engineered and progress in a planned and linear manner.

In contrast, recent theoretical insights from the broader innovation literature highlight the pervasiveness of innovation processes and the important role of collaboration amongst customers (users), competitors and suppliers operating within innovation systems. Innovation theory also emphasises the complex nature of innovation, the role of uncertainty and the emergent non-linear nature of technological developments that are themselves historically constrained and temporally situated. Previous research has attempted to resolve these contrasting perspectives on IT innovation. It has endeavoured to combine macro-level perspectives of innovation theory with the micro-level understandings of IT innovation practice from the IT diffusion and adoption literature (Kwon & Zmud 1987; Mustonen-Ollila & Lyytinen 2003). For example: Swanson (1994) integrates perspectives from organisational innovation to map different types of IT innovation to organisational assets and capabilities; Lyytinen and Rose (2003) explore IT innovation in the context of disruptive innovation theory Christensen (1997) and call for a dynamic theory of IT innovation. Wang and Ramiller

(2009) emphasise the role of acquiring new, or modifying and reinforcing existing IT knowledge, through community interaction. Highsmith and Cockburn (2001) and later Poppendieck and Poppendieck (2003) advocate the incorporation of lean thinking principles into software development practice, facilitating the emergence of customer/user focused agile software methodologies to support IT innovation.

Whilst insights at both macro and micro-levels contribute some understanding of IT innovation, links to contemporary insights from innovation theory are less clear. Current insights emphasise the importance of the objectives and effects of innovation, innovation activities, and linkages in the innovation process for facilitating the transfer and utilisation of knowledge and technology for innovation (OECD/Eurostat 2005). This multi-case study investigation aims to extend existing studies and incorporate broader elements of innovation theory to further consolidate understanding of IT innovation (Dosi 1988; Pavitt 1984; Rosenberg 1994).

Exploring the issues through detailed analysis of literature provided in Chapter 2, several issues worthy of further research have been identified at the intersection of literature associated with information systems research and innovation theory. These issues include the possibility of untested knowledge relating to IT innovation from within innovation theory or from other theoretical domains; the presence of shared and common understandings that seems implicit in the information systems and innovation literature that have not been empirically tested in the context of IT innovation; and conflicting issues across both domains that require further clarification and understanding. An important example is the definitional ambiguity and heterogeneity in relation to the term 'IT innovation' in itself. Where Kwon and Zmud (1987) and later Swanson (1994) provide implicit definitions for IT innovation, there is no clear definition that moves beyond the diffusion and adoption perspective. Nor is there any current guidance or holistic framework or for capturing information about IT innovation that relates directly to the contemporary literature pertaining to innovation.

From the analysis in Chapter 2, and given there is a high degree of uncertainty about the combination factors and the inter-relationships that influence IT innovation outcomes, this thesis aims to co-opt or adapt insights from innovation theory to develop a methodology that can be used to explore case studies where organisations have consciously tried to innovate with IT.

1.2.1 Research Questions

In order to address the research problems identified in the previous section, the following research questions have been formulated:

- **Research Question 1** – How and why do firms innovate with IT?
- **Research Question 2** – How can organisational approaches and experiences in IT innovation be analysed?

1.2.2 Research Objectives

The purpose of this thesis is to investigate information technology innovation practice amongst IT users and producer organisations in order to provide a substantive, theoretical and methodological contribution to understanding IT innovation, anticipating it will be of interest to both information systems and innovation academics alike.

Six high-level objectives were established to meet the aims of this thesis and answer the research questions:

(1) Source or provide a contemporary definition of IT innovation.

(2) Determine why organisations choose to innovate with information technology and how stakeholders make the decision to innovate.

(3) Discover the key activities associated with IT innovation along with who gets involved.

(4) Investigate the consequences and outcomes of IT innovation activity and how benefits are obtained.

(5) Determine the suitability of innovation theory as framework for analysing IT innovation and for guiding further research into IT innovation.

(6) Beyond existing understandings of IT innovation, identify any additional factors that are important for IT innovation and explore how they influence innovation activity and/or organisational outcomes.

1.2.3 Research Scope

To address the research questions and objectives, various resources and processes were utilised for case selection, data collection and data analysis. Together they form the scope of this research.

This research assumes that IT innovation is experienced and observed within human social settings and that these experiences would largely be reliant upon the meanings that people assign to them. As a consequence this research adopted a research philosophy with a subjective ontology and interpretive epistemology using qualitative case study methods for the section and collection of data in conjunction with qualitative-interpretative techniques for data analysis.

1.2.3.1 Selection of cases and participants

This research deployed a multi-case study approach comprising nine organisational case studies of IT innovation. Cases were purposefully selected from organisations involved in the development, implementation and/or use of IT as part of self-reported IT innovation. A key objective in selecting cases was to maximise the opportunity to explore variation in approach and experience (Patton 2002). Selecting cases of different types of innovation, different areas of application, and different organisational contexts achieved this variation. Variation also included selecting cases with organisations of different size, geographical scope and primary business activity. Cases included organisations from both the IT producing and IT user sectors.

Key personnel who were closely involved with IT innovation activity in each case were selected as the unit of observation for this research. In most cases a single participant was adequate to provide a detailed account of IT innovation. Multiple participants were selected in cases where there was substantial complexity, specialisation or external sourcing.

1.2.3.2 Data collection methods

The primary source of data for the case studies was data collected from participants during semi-structured interviews. Secondary data was also collected from organisational documents related to the IT innovation. The researcher collected field notes during and after interviews to provide contextual support for subsequent analysis. Interviews were conducted using a semi-structured interview protocol designed to generate insights into the approaches, experiences and impacts of innovation. All interviews were audio-recorded and transcribed within 24-36 hours of the conduct of each interview. In most organisations it was possible to subsequently contact and verify specific details generated during semi-structured interviews via telephone or a subsequent follow-up interview.

1.2.3.3 Techniques used of data analysis

Data analysis was conducted in two stages. Stage one involved analysis of data from each individual case, organisational documents and field notes. Stage two involved cross-case analysis.

During the first stage interview transcripts were coded and analysed for each case using an inductive (data driven) approach. The analysis was broadly based on the recommendations provided in Miles & Huberman (1994) and deployed the detailed thematic analysis techniques described in Braun & Clarke (2006) and Attride-Stirling (2001). Organisational documentation and field notes were utilised to assist in providing a context statement for each case and to assist with understanding the IT innovations investigated during interview.

During the second stage emergent themes from each case were reviewed, compared and contrasted using an iterative process based on the analytical approach advocated by Miles & Huberman (1994). Similarities and differences across cases were identified and organised using meta-matrices structured around related themes, social structures and information technology artefacts in order to categorise the diversity of approaches and experiences in IT innovation practices. The results of this cross-case analysis were interpreted to produce an empirically grounded model of IT innovation.

1.3 Summary of contribution

At a substantive level this thesis presents an in-depth study of nine Australian organisations, their approaches and experiences with IT innovation. It presents a dynamic model of IT innovation (Section 6.3) that confirms the importance of mechanisms that combine domain knowledge with new and existing IT assets and capabilities to create platforms for continuous innovation. In particular, it acknowledges the role of requirements management and user feedback processes that can be used to improve the prospects of diffusion and derive extended and unanticipated benefits over longer time frames.

At a theoretical level this thesis initially presents a heuristic model (Section 2.5) drawn from the empirical guidance used in innovation studies to address problems relating to IT innovation found within the IT/IS literature. The heuristic model was also developed to allow researchers to explore and analyse IT innovation practice more effectively. Through the research process the heuristic model was reinvigorated and advanced through the development of a dynamic model of IT innovation relating to the case studies of IT innovation practice (Section 6.3). The model was again further enhanced with the development of a knowledge framework to guide future research of IT innovation phenomena (Section 6.5).

At the methodological level this research initially demonstrates how innovation theory can be used to guide elements of data collection relating to IT innovation. The dynamic model of IT innovation generated from the case studies then illustrates how data collection and analysis can explore the activities and events associated with the design, development and diffusion of IT innovations to reveal the continuous and incremental development processes; the role of IT assets and capabilities in IT innovation decisions, activities and outcomes over time; and the collaboration and interaction amongst stakeholders working on IT innovations within various diverse social and organisational settings.

This research also identifies issues defining and understanding IT innovation phenomena within the IT/IS literature and presents a modified knowledge framework (Section 6.5) that incorporates contemporary innovation theory in order to facilitate and guide research looking to explore IT innovation phenomena.

1.4 Thesis outline

This section provides a brief overview of the remaining chapters of this thesis.

Chapter 2 – Literature Review

Chapter 2 presents an overview of the research literature relevant to the study of IT innovation. It identifies research issues and problems associated with IT innovation in the context of information systems research and innovation theory. The research issues and problems are then used to formulate research questions and justify the purpose of this research. The literature is also utilised to develop a heuristic device that is used to plan and guide data collection and analysis.

Chapter 3 – Methodology

Chapter 3 presents the research design and methods used to conduct this research. It describes and justifies the research philosophy, strategy and the procedures used for data collection and analysis. It also outlines the approach taken for interpretation and discussion, the ethical considerations and reflections on the limitations of this research.

Chapter 4 – Data Analysis Part 1

Chapter 4 provides the first of two phases data analysis, reviewing the themes, social structures and information technology artefacts emerging within each of the nine cases studies of information technology innovation.

Chapter 5 – Data Analysis Part 2

Chapter 5 presents the second phase of data analysis exploring the themes, social structures and information technology artefacts across all cases. Cross-case analysis allows themes and concepts to be evaluated and refined in different context (Darke, Shanks & Broadbent 1998), deepening understanding and explanation and addressing tensions between the particular and the universal (Miles & Huberman 1994).

Chapter 6 – Interpretation and Discussion

Chapter 6 provides an interpretation and discussion of the data analyses conducted in Chapter 4 and Chapter 5. This chapter consolidates the findings from the case study analysis and generates a dynamic model of IT innovation based on organisational approaches and experiences in IT innovation. It then discusses the model and findings in the context of existing research literature to examine similarities, differences and gaps within current theory. Based on this interpretation and discussion it then presents a knowledge framework designed to extend exiting understanding of organisational approaches and experiences in IT innovation. To conclude this chapter presents a synthesis of the key findings in relation to the research problem and questions associated with this research.

Chapter 7 – Conclusions and Future Work

Chapter 7 outlines the conclusions of this research. A review of all major findings is discussed along with an outline for future work.

1.5 Chapter summary

This chapter has provided an introductory background and summary for this thesis. It identifies the research problem and highlights the research questions and objectives for this study. This chapter also discussed the contribution this thesis provides to information systems theory and practice at the substantive, methodological and theoretical level in the context of IT innovation. The chapter concluded by providing a summary review of the thesis structure outlining the remaining six chapters.

In the next chapter a review of the information systems and innovation literature is presented in conjunction with a theoretical framework. This theoretical framework formed the basis the research questions and objectives described earlier this chapter.

2 LITERATURE REVIEW

2.1 Introduction

The following chapter presents an overview of the research literature relevant to the study of IT innovation. It identifies research issues and problems associated with IT innovation in the context of information systems research and innovation theory. The research issues and problems are then used to formulate research questions and justify the purpose of this research. The literature is also utilised to develop a heuristic device that is used to plan and guide data collection and analysis.

The methodology employed for this research sees the literature used in two stages. In the initial stage and forming the basis of this chapter, it is used to justify the research and provide an initial guide for data collection and analysis. Later as part of the interpretation and discussion of the findings in Chapter 6, the literature is reintroduced or enfolded (Eisenhardt 1989b) to allow critical comparison+s with the extant literature in order to extend theory associated with IT innovation.

The chapter is structured in the following sections:

- Section 2.2 provides background to the research. It also outlines key assumptions and definitions associated with this research.
- Section 2.3 provides a review of the literature associated with the development, implementation and use of IT. It provides a discussion of the organisational value of IT and various methods for design, development and implementation of IT.
- Section 2.4 outlines the foundations of innovation theory and provides a review and discussion of the literature associated with innovation research.
- Section 2.5 reviews the theoretical concepts from the literature highlighting the gaps and identifying research issues for further study in this research.
- Section 2.6 concludes the chapter, summarising key elements of the chapter.

2.2 Theoretical background

Arthur (2009) describes technology as a programming of nature and a mechanism for capturing phenomena in a way that they can be harnessed for some (human) purpose. The term technology can also be used in a collective form to describe a body, industry or collection of technologies (Arthur 2009). This research utilises information technology as an umbrella term for a class of technologies that exploit our knowledge of electronics and semiconductors to represent information in the form of discrete binary numerical data. It also uses information technology as a collective term to describe the broad range of devices, components, understandings and practices used to collect, store and manipulate data.

In practice, information technologies exist with varying degrees of complexity. They broadly incorporate (1) hardware, the physical devices and components; (2) software, routines and processes that enable hardware to collect, store and manipulate data; and (3) architecture, the understandings, methods and practices for combining hardware and software for specific purposes (Carr 2005). Information technologies have a broad range and variety of uses within the economy and can be described as being a general-purpose technology (Brynjolfsson & Hitt 2000).

The term information system is often used interchangeably and in conjunction with references to systems involving information technology. Although information systems technically cover the broader interaction between information, technology, processes and people. As an academic or theoretical discipline information systems (IS theory) covers the design, development, implementation and use of information technology within organisations and society (Avison & Elliot 2006).

A connected and related discipline theory is computer science. Computer science covers the theories and practices associated with the invention and design of information technology and computational systems. Computer science is focused solving computational design and architectural problems, but it is not particularly concerned with information technology delivery and implementation issues. A number of important research streams exist within IS theory and computer science that deal both directly and indirectly with IT innovation.

IS theory itself draws from diverse range of reference disciplines (including computer science) and tends to emphasise the understanding of information technology development issues as opposed to focusing on computational theory and design problems. As a consequence we find most of the direct coverage of what would be IT innovation research issues within the IS literature.

To obtain a full understanding of IT innovation this research must also explore the foundational issues associated with innovation itself. In contrast to IS theory, innovation theory provides a broader level of understanding of higher-level issues associated with innovation itself.

Innovation can be described as act of putting new ideas and designs into practice, where innovation is a key component of technological change (Schumpeter 1934). Innovation theory is concerned with 'how innovation takes place and what the important explanatory factors and economic and social consequences are' (Fagerberg, Fosaas & Sapprasert 2012, p. 1132).

The subsequent sections of this chapter provide a detailed review of IS theory and innovation theory with a view to providing the theoretical coverage required to obtain an understanding of what IT innovation is, how IT innovation might be achieved, and how IT innovation might be effectively analysed.

2.3 The development, implementation and use of IT

2.3.1 Introduction to information systems approaches

Avison and Elliot (2006, p. 5) describe the scope of information systems theory (IS theory) as encompassing 'the effective design, delivery, use and impact of information [and communications] technologies in organizations (sic) and society'.

IS theory draws from diverse range of reference disciplines (including computer science) and tends to emphasise the understanding of information technology development issues as opposed to focusing on computational theory and design problems. The development, implementation and use of IT provide the foundational elements of understanding IT innovation. Important themes within the literature include:

- Factors and mechanisms by which organisations and the economy can extract or realise value from IT investments.
- Methods, techniques and processes associated with the design, development and implementation of IT.
- Sources of knowledge required to progress IT development and implementation.
- Actors, agents and institutions (rules) and networks involved in development, implementation and use of IT.
- Diffusion and adoption of IT innovations.

2.3.2 The organisational value of IT

A range of mediating organisational factors influences the value of information technology investments. During the last fifty years there has been an unprecedented rate of improvement and technological change relating to information technology. As a consequence, information technology is now pervasive in most modern economies. Specialised industrial sectors have emerged to address the demand for information technology products and services. In March 2015 information technology related businesses made up more than a fifth of the world's 100 most valuable companies by market value (Financial Times 2015). As the sector continues to evolve new industrial ecosystems are emerging to address complexities, generate economies of scale and exploit opportunities for systems modularity.

By design information technologies are inherently configurable and/or programmable. They are also routinely adapted and modified for use in a broad range and variety of applications throughout the economy. Freeman (1991, p. 303) explains that 'some new technologies open up a wide range of possibilities for further innovation in many sectors of the economy'. Technologies that exhibit a broad range and variety of use for innovation fit within special category of technology referred to as general-purpose technologies (GPTs) (Bresnahan & Trajtenberg 1995; Freeman 1991; Lipsey, Carlaw & Bekar 2005). Bresnahan and Trajtenberg (1995, p. 83) describe these technologies as 'technological prime movers' and suggest that they are characterised by 'pervasiveness…, inherent potential for technical improvement and innovation complementarities giving rise to increasing returns to scale'. However the immediate identification a GPT can sometimes be problematic because they tend to emerge or evolve over time. Lipsey, Carlaw and Bekar (2005, p. 1) emphasise that 'GPTs are not just born in their final form, they often start off as something we would never call a GPT and develop into something that transforms an entire economy'. Information technology exhibits many if not all of the characteristics of a GPT.

The question of economic returns and the organisational value associated with information technology investments have long been debated in the economics and information systems research literature. Information technology has been shown to create economic value through a number of different but complementary mechanisms, including capital deepening; multifactor / complementary interactions; and structural deepening.

Capital deepening is the process of introducing additional capital into an economy relative to labour. The conceptual upside of capital deepening is that as output increases the overall productivity per worker in the economy increases. Information technology is frequently viewed as a capital good, the embodied knowledge of a productive purpose associated with information processing (Baetjer 1997). Access to information technology capital for task automation or even complete labour substitution is a form of capital deepening involving information technology. This is possibly the most obvious way to exact value from information technology (or any form of capital for that matter). For some economists capital deepening is said to be subject to diminishing returns i.e. not sustainable, but it is also possible to argue for it to be a continuous process when it is reinforced by technological progress and structural deepening (Arthur 2009).

Multifactor interaction refers to the disposition of information technology to provide complementary or joint effect improvements for other non-labour production factors (Dedrick, Gurbaxani & Kraemer 2003; Pilat 2004). A practical example multifactor interaction is where IT might be used to improve the quality of a product or service, or provide timesaving for employees, suppliers or customers. The impact of multifactor interactions between information technology and other complementary assets is thought to be the most significant beneficial outcome of information technology investment (Brynjolfsson & Hitt 1998).

Structural deepening occurs as technologies evolve and become more complex. Subsystems and component innovations emerge from a need to manage complexity and overcome limitations of the technology (Arthur 2009). In effect incremental innovations occur relating to the technology in itself. Structural deepening associated with information technology has given rise to economic activity associated with new markets and industry that focus on the efficient production, management and delivery of complex information technology components and services. It has also produced spill over activity in related industries and information intensive domains.

Whilst the economic and organisational value of information technology can be derived through one or a combination of the three mechanisms identified above, other factors have also been shown to influence the realisation of benefits associated with the development, adoption and use of information technology.

Detailed measurement of multi-sector longitudinal data at the organisation level has shown that development, adoption and use of information technology can make a significant contribution to organisational value (Brynjolfsson & Hitt 1998). However this value has been shown to vary significantly from organisation to organisation and the realisation of this value appears to be influenced by unique organisational factors or attributes that must be appropriately configured and aligned for the complementary mechanisms to take effect (Brynjolfsson & Hitt 1998). Brynjolfsson & Hitt (1998) emphasise that up to half of the value generated by information technology investments is influenced by unique characteristics within the using organisation and that configuring these unique characteristics was a costly and time consuming process. The firm effect variation is a significant finding in terms of understanding how value can be extracted from information technology investments. It points to an important feature of information technology development, adoption and use, that suggest outcomes are contingent upon the availability and capacity to exploit complementary assets, innovations and/or circumstances.

Notions concerning the role of assets and capabilities and their relationship to organisational performance are extensively covered by the management science literature. The resource-based view of the firm (resource-based theory) proposes that firms can achieve above average returns (competitive advantage) by harnessing resources (assets and capabilities), that are valuable, rare, difficult to imitate and unable to be easily substituted by a competitor (Barney 1991).

Resource-based theory has also been utilised in the information systems literature to explain the multifactor interaction mechanism and the role information technology resources play in generating economic and organisational value (Wade & Hulland 2004). The main challenge for researchers within this domain has been to demonstrate how information technology resources provide competitive advantage, where clear arguments can be established to suggest that whilst information technology is valuable, it is not rare, and is often easy to copy or substitute (Clemons & Row 1991; Keen 1993; Powell & Dent-Micallef 1997). Several researchers have sought to address this issue by examining in greater detail the interactions of information technology with other resources.

Clemons and Row (1991) argue that information technology creates competitive advantage by leveraging or exploiting pre-existing human and business resources (Powell & Dent-Micallef 1997). Ross, Beath and Goodhue (1996) and Bharadwaj (2000) argue that that competitive advantage from information technology lies in the development of effective information technology capabilities.

Resource-based theory makes a distinction between firm assets and capabilities. Amit and Schoemaker (1993) describe a capability as a special type of resource or abstract intermediate good that as the capacity to coordinate other resources for enhanced productivity. Amit and Schoemaker (1993) emphasise that capabilities are often information-based processes developed over time through complex interactions with firm resources. Ross, Beath and Goodhue (1996) emphasise three important capabilities: (1) highly competent information technology human resources, (2) a reusable technology base and (3) strong business management and information technology (function) relationships.

Bharadwaj (2000) elaborates on the concept of information technology as an organisational capability and demonstrates that firms with high information technology capabilities outperform others. Bharadwaj (2000) presents a modified scheme of information technology resources: (1) information technology infrastructure, (2) human information technology resources, and (3) information technology enabled intangibles (customer orientation, knowledge assets, synergy across business functions). Wade and Hulland (2004) argue that information technology assets (infrastructure) are easiest to copy and the most fragile source of competitive advantage. However, firms with superior information technology deployment capabilities and intangible assets are better placed in terms of obtaining competitive advantage. An important element of the modified Bharadwaj (2000) scheme is the elaboration of information technology intangibles and the recognition of the role that information technology resources play in facilitating the accumulation of intellectual capital and the formalisation of knowledge assets.

Cohen and Levinthal (1990) define a firm's ability to recognise the value of new information, assimilate it, and apply it to commercial ends as a firm's absorptive capacity. In the context of absorptive capacity, Dewett and Jones (2001) propose that information technology has the capacity to improve a firm's ability to process new knowledge or reconfigure existing knowledge. Roberts et al. (2012) review the existing information systems literature and suggest that absorptive capacity should play a role in understanding the value of information technology, however it has rarely been examined in this context. One exception is Bolívar-Ramos, García-Morales and Martín-Rojas (2013) that provides an empirical investigation of 160 European high tech sector firms that verify a direct and positive effect associated with information technology technical skills and the use of information technology with respect to absorptive capacity.

The continued growth and investment in information technology goods and services is presumably underpinned by an expectation that information technologies have significant capacity to provide economic and/or social returns (Brynjolfsson & Saunders 2010). Whilst resource-based theory offers an important perspective on the role of information technology resources to generate economic and organisational value, it has long been criticised for not addressing the evolutionary nature of capabilities and the impact of innovation-based competition within dynamic markets (Teece, Pisano & Shuen 1997).

Teece, Pisano and Shuen (1997) propose an extension to resource-based theory known as dynamic capabilities. Dynamic capabilities emphasises the importance of the firm's ability to develop and reconfigure resources in rapidly changing competitive environments. (Wade & Hulland 2004, p. 107) suggest that information technology resources to 'may be particularly useful to firms operating in rapidly changing environments' and propose that information technology resources share many of the attributes associated with dynamic capabilities.

Eisenhardt and Martin (2000) argue that dynamic capabilities are important, but their value is fundamentally linked to the resource configurations they create and not in the capabilities themselves. McAfee and Brynjolfsson (2008) also appear to support this perspective emphasising that value from information technology resources comes from process innovation.

Kohli and Grover (2008) provide a useful synopsis of current understandings of IT investment value as follows:

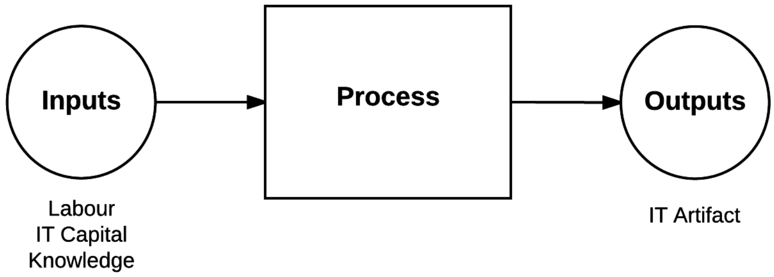
- There is an established critical mass of research that demonstrates the value of IT investment that can be 'financial, intermediate (process-related) or affective (perception-related)'(Kohli & Grover 2008, p. 23).
- IT creates value under certain conditions and in conjunction with other complementary resources.
- Value is manifested in many ways and at different levels i.e. individual, group, firm, industry or process.
- Creating competitive advantage i.e. sustainable returns from IT is possible but difficult due to the ease of substitution and imitation. Leveraging unique complementary resource relationships is the key to creating IT based competitive advantage.
- IT value can be latent i.e. in some cases it is not immediate and may lag the initial investment by some time. IT can also be treated as an option in that it has the capacity to generate value later or when the need arises.
- IT value is difficult to measure.

2.3.3 IT design, development and implementation processes

There is a substantial body of knowledge relating to the methods of design, development and implementation of information technologies. For most parts, this literature presumes that information technology developments are predominantly engineered i.e. information technology artefacts are planned and constructed new versions of known or pre-existing technologies (Arthur 2009).

At very general level information technology can be conceptualised in terms of a basic input-process-output (IPO) model (see figure 2-1). Where information technology capital, labour and knowledge are placed into a development process to produce an information technology artefact (Smyrk 1995).

Figure 2-1 IPO development adapted from Smyrk (1995).

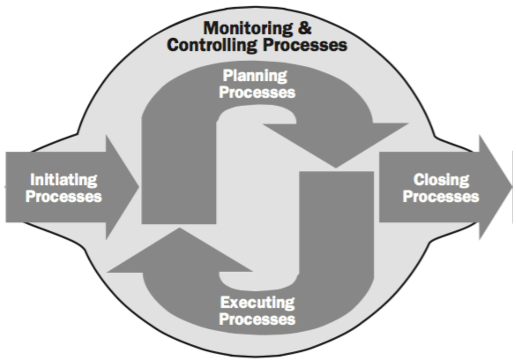


Whist specialised methodologies are utilised to progress different types of development, almost all information technology developments follow the generic development sequence attributed to project management i.e. ‘starting the project, organizing and preparing, carrying out the project work, and closing the project’ (PMI 2013, p. 1).

Project management has a long history in construction and engineering. With its roots in Taylorism and Scientific Management the mainstream methods of project management are still arguably plan-based and inspired by the discipline of engineering (Morris 2013). Early techniques in project management emphasised project scheduling and resource management, but methods have now evolved to focus on process and knowledge oriented models generated from practice-based experience. Project management methods have historically been very pervasive in information technology development. So much so that several mainstream business oriented project management methodologies have been heavily influenced by information technology development concepts (for example PRINCE2).

Since 1996 the United States based Project Management Institute (PMI) has maintained and published a set of guidelines or good practice relating to project management. The Project Management Body of Knowledge (PMBOK) provides a useful background in understanding the processes associated with the project management discipline. PMBOK (PMI 2013) describes projects as having two categories or types of process – project management processes and product-oriented processes. The latter being specific to the product or output of the project and vary considerably across industries. PMBOK seeks to describe and elaborate the project management processes. PMBOK (PMI 2013) divides project management processes into five process groups – initiating processes, planning processes, executing processes, monitoring and controlling processes and closing processes. Figure 2-2 illustrates the conceptual process and interactions.

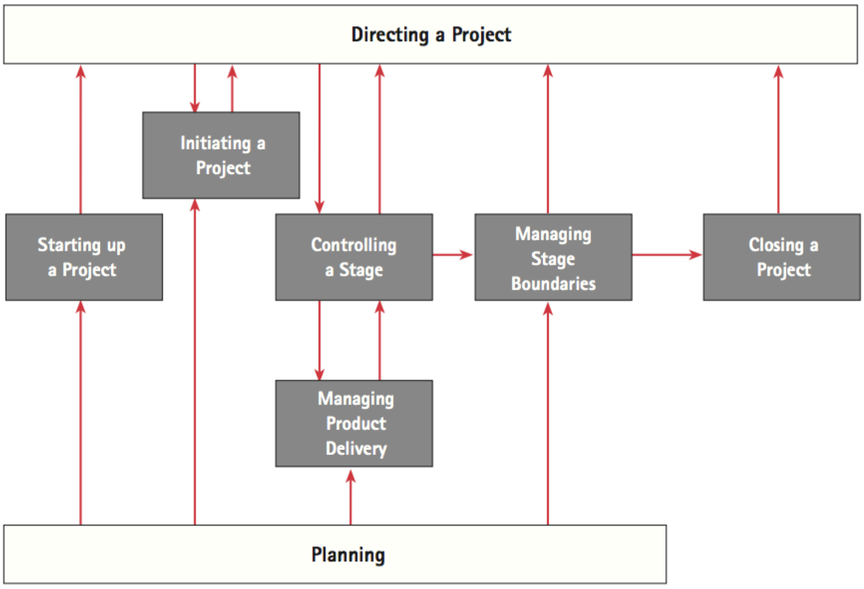
Figure 2-2 Common project management process interactions (PMI 2013).



PMBOK(PMI 2013) emphasises that whilst the process groups are presented as elements with discrete interfaces, in practice they overlap and interact within and across phases. Supporting the process groups, PMBOK(PMI 2013) defines ten knowledge areas that are used to further specify as many as 47 discrete and practical project management processes that can be utilised by project managers and teams to manage projects.

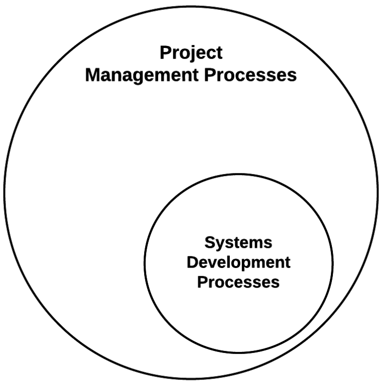
Similarly PRINCE (PRojects IN Controlled Environments), now PRINCE2 is a highly recognised project management methodology originally developed to provide improved guidance for information systems projects (OGA 2009). PRINCE2 (OGA 2009) takes a very similar process based perspective for which activities are further elaborated and specified (see figure 2-3).

Figure 2-3 The PRINCE2 process model (OGA 2009).



Product-oriented process views of how information technologies are developed and diffused are commonplace. In particular there is an extensive body of knowledge devoted to the methods of design and development of information systems and software. In line with the PMBOK notion of product-oriented processes, information systems development methodologies can be conceptualised as a subset of the overall development and implementation process (see figure 2-4).

Figure 2-4 the relationship between project management processes and systems development processes (Avison & Fitzgerald 2006) .



2.3.3.1 Methods for the design, development of information technology

Methods for the design, development of information technology are extensively covered in the information systems and computer science literature (Avison & Fitzgerald 2006). A number of different process models and techniques have evolved through decades of research and practice, particularly in the context of software design and development. Avison and Fitzgerald (2006) describe the evolution of models as moving through various eras. Models evolving from those with a limited planning and analysis focus, through an era of formal plan-based methods, and on to the contemporary adaptive delivery focused methods commonly associated with lean and agile models.

Early developments in information systems were predominately programing oriented. Boehm (1988, p. 61) refers to the process as 'code and fix' where systems were developed with minimal planning – 'write some code then fix the problems'. Engineers and programmers soon realised that the code and fix approach didn't scale. As systems became more complex they became difficult to improve and maintain.

Structured or plan-based methods for systems development soon began to emerge. Inspired by engineering techniques (Fowler 2001), efforts were made to recognise the importance of planning and design to guide the development process. Emphasis was also placed on verification of the finished product against the requirements. What is now known as the systems development life cycle (SDLC) was born from this plan-based approach. There are many variations of the SDLC, however a generic summary of the stages are summarised in Table 2-1.

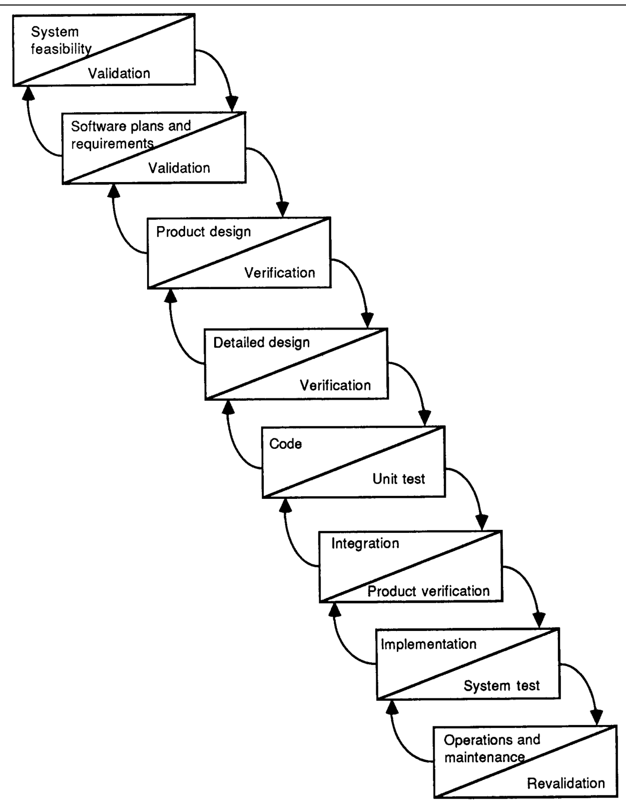
Table 2-1 SDLC stages and typical activities

Stage		**Activity**
1	Planning and analysis	Scoping and setting up the initiative, converting user or customer requirements into meaningful specifications for the proceeding stages.
2	Design	Using the requirements and domain knowledge to plan what components, modules and interfaces will be required and how they will be organised (or architected), providing a basis for construction, configuration and/or acquisition.

Stage		Activity
3	Development/Construction	Creating, building and/or assembling the design, usually to some agreed standard or level of quality. In the case of software development this would be coding, in the case of hardware, this may be a combination of assembly and interfacing. Where commercial of the shelf software (COTS) are concerned it may involve selection and configuration.
4	Verification and testing	Evaluating the quality of construction, ensuring it is fit for purpose and responding to issues and defects.
5	Deployment and operation	Handing the system over to operations, evaluating its performance and in many cases establishing a framework to maintain and improve the system over its lifecycle.

The most widely cited form of the planned-based methodologies is the waterfall model. Whilst this form has often been used to describe the shortcomings of highly planned linear development methodologies (Boehm 1988; Royce 1970), the waterfall model was essentially the first of the plan-based models to recognise the need for feedback and verification through different stages of the SDLC.

Figure 2-5 the waterfall model (Boehm 1988)

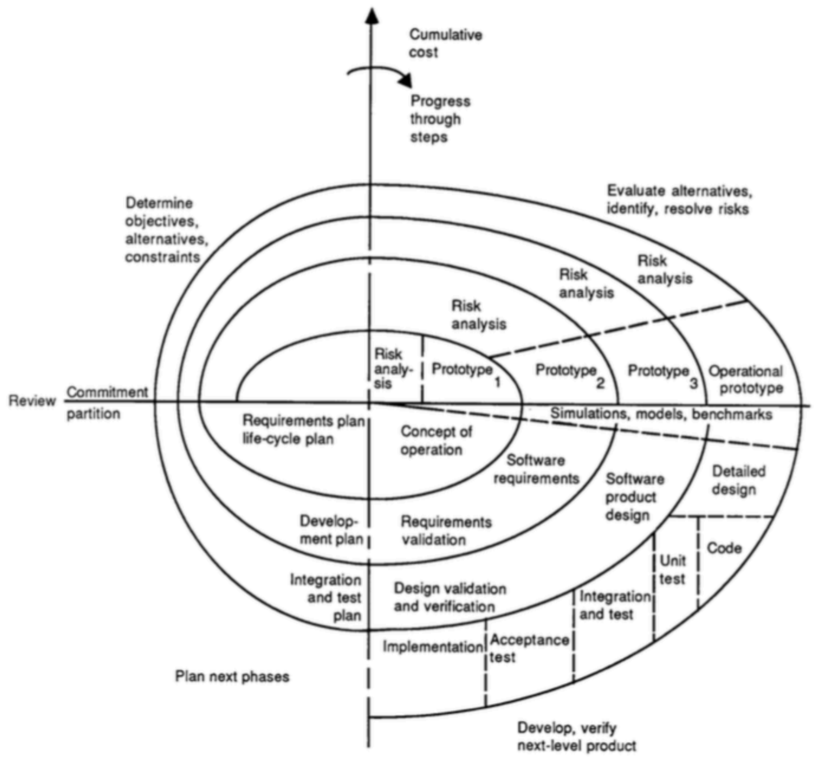


Despite its improvement over the linear models, the waterfall model suffered catastrophically at the hands of poorly defined requirements. Such a characteristic was synonymous with the end-user computing technology that emerged from the PC era and arguably continues to this day.

The main problem for the waterfall model is ending up with a product or system with too many faults, having spent significant resources getting to the implementation and system testing stage (Leffingwell & Widrig 2000). As a result, incremental and iterative type methods began to emerge, with techniques that were more sensitive to the design and development risks associated with unclear or poorly understood requirements.

Boehm (1988) was one the first to explore the application and use of incremental improved prototypes in the software development lifecycle. The associated “spiral model of development” (Boehm 1988) being the foundation for many subsequent incremental software development models. Whilst numerous variations of the incremental development model exist, the majority of them are predominately plan-based and hold true to the engineering inspired concept separating planning and design from construction (Fowler 2001).

Figure 2-6 Boehm’s spiral model (Boehm 1988)



In practice, many of the plan-based models failed to deliver the productivity required to keep pace with demand for development through the emerging era of Internet computing. Concerns emerged from developer communities that the plan-based models were too complex and that they were weighed down by the heavy burden of bureaucratic planning and design documentation (Avison & Fitzgerald 2006).

As a consequence a new adaptive process model evolved with the primary goal of satisfying the customer and focusing on reducing the impact of change throughout the systems development life-cycle (Highsmith & Cockburn 2001). Agile methods as they are more commonly known, refer to a family of design and development techniques that advocate a lean style of product development for software (Womack, Jones & Roos 2001). The lean style (of thinking) has it origins with the Toyota Production System used to manufacture vehicles in post World War II Japan. The fundamental principle associated with lean thinking is the elimination of waste, where waste is defined as “anything that does not create value for the customer” (Poppendieck & Poppendieck 2003). Agile methods recognise the value of planning and process but preference individual interaction as being more effective at reducing waste, particularly when used in conjunction with a collaborative developer-customer project environment.

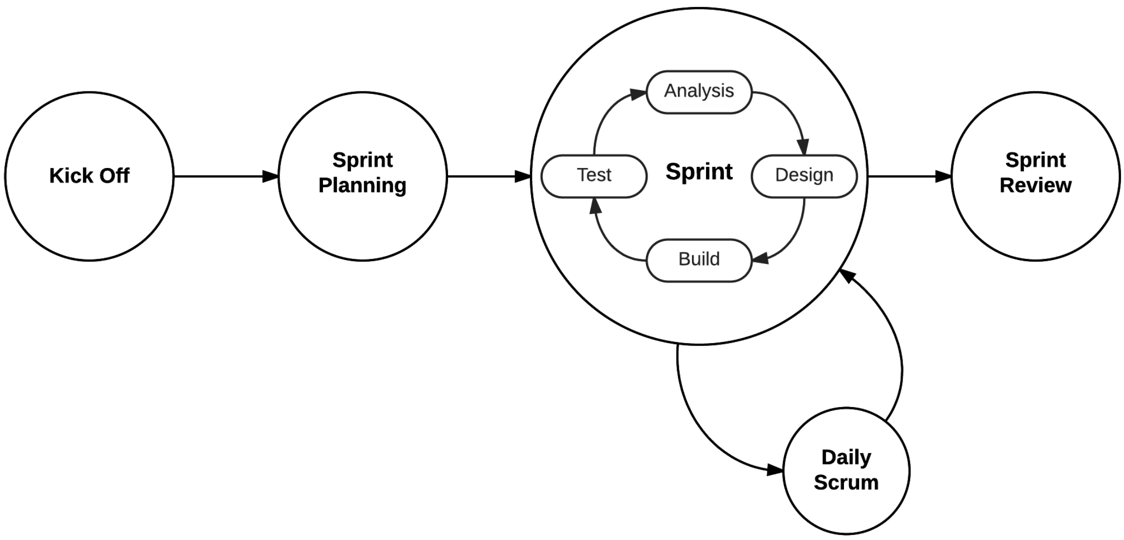
Highsmith and Cockburn (2001, p. 120) outline a basic set of principles referred to as the Agile Software Manifesto that values ‘individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, responding to change over following a plan’.

Like the planned based models there are a number of adaptive or agile methods that have emerged over the last decade or so. A well-recognised and researched agile method is the Scrum methodology. The Scrum methodology (Scrum) provides an excellent illustration of the agile development model. Scrum accepts there will be frequent changes in requirements, time-frames, resources and technology throughout the systems development life-cycle (Abrahamsson et al. 2002). It comprises of three components – roles, processes and artefacts (Cervone 2011). Whilst many of the benefits of Scrum are found in the unique application of roles, artefacts and its adherence to many of the general agile principles, the process model is in effect a phased and incremental approach.

Schwaber (1997) describes Scrum as having three distinct phases – (1) a pre-game phase involving the overall planning and architecture, (2) a development phase called a sprint that focuses on incremental feature and function building, and (3) a closure phase where the product is readies for deployment or release.

From a process perspective the unique and typically agile approach utilised in the Scrum methodology is in the development phase. Cervone (2011) provides a detailed description of this workflow that is linked to five events or activities – (1) the kick-off – defining the high-level requirements and goals; (2) sprint planning – further defining the requirements with the product owner and the development team, prioritising and setting goals for the development; (3) the sprint – an empirical development process but essentially an interactive cycle of analyse, design, build and test activities. The sprint would extend over a defined time period that is adjusted for teams and circumstances; (4) a daily scrum – a daily meeting supporting the sprint process reviewing progress, the plan moving forward and discussing any issues that are interfering with progress; and finally (5) the sprint review – back to the team and the product owner to demonstrate what has been achieved. The scrum workflow itself is illustrated in figure 2-7, during the sprint process the requirements do not change until the next sprint planning event and after the review. Unlike structured methods documentation is kept to a minimum and meetings are informal and interactive (Cervone 2011).

Figure 2-7. The Scrum development workflow, adapted from Cervone (2011)



Poppendieck and Poppendieck (2003) extend the foundations of agile development by incorporating the lean concept of waste into the software development process. Poppendieck and Poppendieck (2003) translate "the seven wastes of manufacturing" originally identified by Shingo and Dillon (1989) into their software development equivalents (see Table 2-2 below).

Table 2-2 The seven wastes of software development (Poppendieck & Poppendieck 2003).

	Software development waste	**Manufacturing waste equivalent**
1	Partially Done Work – software development that is incomplete or yet to be integrated into a finished product.	Inventory
2	Extra Processes – software design and analysis processes that do not contribute to customer value e.g. documentation that will never be accounted for.	Extra Processing
3	Extra Features – features that were not required add complexity and maintenance overheads.	Overproduction
4	Task Switching – having developers switch between tasks or projects e.g. assigning people to multiple projects.	Transportation
5	Waiting – delays in software development processes.	Waiting
6	Motion – how easy is it to access information pertaining to development e.g. if the developer has a question on requirements how long does it take to get an answer.	Motion
7	Defects – faults or problems in software and how long does it take to identify them.	Defects

Poppendieck and Poppendieck (2003) elaborate on the seven wastes to provide guidance on how they can be addressed in software development. Tactics recommended by Poppendieck and Poppendieck (2003) include – employing concurrent/iterative development approaches in order to "delay decisions until the last possible moment so you can make the most informed decision possible" through feedback cycles; and delivering software as fast as possible so as to identify defects and reduce waiting times.

Traditionally systems development methodologies have been well diffused but not necessarily fully adopted by practice (Agarwal & Prasad 2000; Fitzgerald 1998). Adaptive-agile methods have reportedly achieved a greater level of acceptance (Dybå & Dingsøyr 2008) and have realised improvements in time to market, productivity and cost (Reifer 2002). However it is argued that such outcomes may be driven more by organisational culture rather than being dependent the adoption of agile methodologies (Chow & Cao 2008).

Despite there being a significant body of research associated with agile methods there is little empirical evidence to demonstrate the extent of adoption within information technology developer communities (Chan & Thong 2009). Norton (2008) suggests that penetration of agile methods is high but that its adoption (use in projects) has been overstated. Well-argued alterative perspectives also exist as to the extent to which development processes, models and methodologies can impact development productivity, reliability and complexity.

Brooks (1987) proposes that systems complexity is driven by two mechanisms – (1) problems created by engineers through the process of development; and (2) issues associated with the type of problem to be solved in general. Process and technique modifications arguably focus on the former, where technology improvements tend to assist with the latter. Brooke's (1987) main argument is that complex problems associated with processes and techniques represent less than a tenth of the overall problems in most projects i.e. its more about the problems you are trying to solve.

From a process perspective the SDLC is much maligned in terms of representing a real world workflow, however the illustrated examples taken from the various eras arguably demonstrate that the staged life-cycle model still pervades much of the thinking. The emphasis here is on thinking, as the SDLC is more conceptual than pragmatic and perhaps more of a taxonomy or organising framework for the activities associated with the development information technology solutions. Thus the SDLC is a useful construct for understanding the design, development and implementation of information technology.

2.3.3.2 Implementation methods and processes

Not all information technology developments involve software design. Many developments involve the novel modification and configuration of externally procured technology. The implementation of information technology has also been shown to have a significant influence upon organisational and social behaviour (Markus 2004) and many developments must therefore focus on implementation and deployment issues.

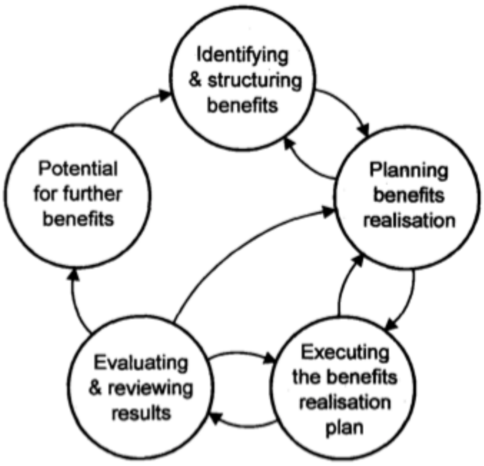
Various perspectives prevail in relation to how information technology change can be introduced into organisations. They differ considerably and range from delegating the responsibility into the domain of organisational change management, through to incorporating methods into project management processes to improve the realisation of benefits from information technology development. Three themes pervade the literature in respect to IT implementation processes – (i) the application of organisational change management theory, (ii) specialised tactics for IT benefit realisation, and (iii) business process management based perspectives.

IT/IS research has been as much about the context of implementation as it is about the IT artefact. Organisational change management theory is routinely applied to IT/IS implementation research scenarios. For example, Kwon and Zmud (1987) utilise Leavitt (1965) change management model comprising four interacting organisational components – task, technology, structure and people. The model argues that changes in one of the components can have an impact on the other components. Kwon and Zmud (1987) added a filth component environment that represented factors such as the heterogeneity of environmental entities, uncertainty, competition, resource concentration and dispersion, and inter-organisational dependences.

Markus (2004) argues that one of the biggest risks associated with IT development is that the users will not utilise the newly deployed information technologies and/or related work processes. It is agued that project management and organisational change management processes on their own are unable to adequately address this issue, and that the implementation of IT projects require a process of technochange that focuses on the completeness and alignment of IT developments. Markus (2004) outlines three conditions that characterise a successful technochange process – (i) the solution that is capable of yielding the desired results if it is properly implemented, (ii) the solution is used effectively, and (iii) the benefits of the solution are actively captured. To achieve these conditions Markus (2004) advocate incremental change and the use of prototyping, not just with the product, also with business benefit realisation.

Ward, Taylor and Bond (1996) introduce a benefit management process model for the realisation of IT/IS benefits. The model comprised five interacting elements – identifying and structuring the benefits, planning the benefits, executing the benefits realisation plan, evaluating and reviewing the results, and identifying potential for further benefits (see figure 2-8).

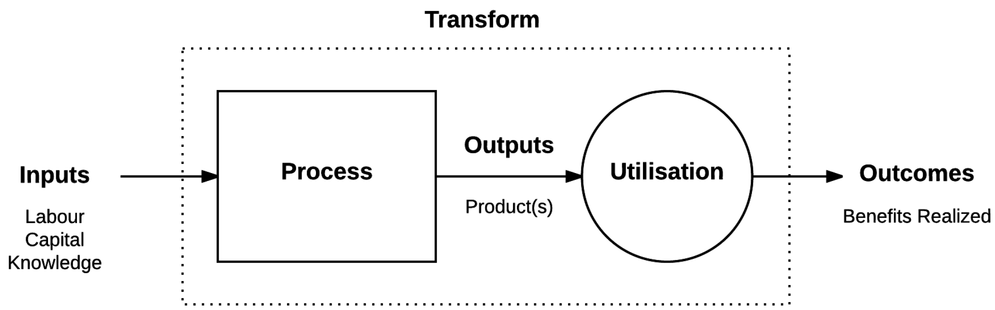
Figure 2-8. Process model of benefits management (Ward, Taylor & Bond 1996)



Ward, Taylor and Bond (1996) also conducted an empirical study to evaluate the relevance of benefits management. The finings included: (i) that very few organisations employed a benefits realisation process, although just over half had formal systems, project and investment methodologies; (ii) many organisations found it difficult to identify or quantify benefits; (iii) project managers were seldom responsible for benefits realisation; (iv) that post implementation reviews were technical or time/cost focused; and (v) benefits were overstated to gain approval. Ward, Taylor and Bond (1996) concluded that a benefits realisation processes on its own is not enough, and that it needed to be integrated into project management methodologies or have the project management methodologies built around benefits realisation.

Smyrk (1995) argues that IT/IS implementation projects should be scoped and managed in a fashion that recognises that outputs in themselves do not generate benefits, those outputs must be utilised and that the transformation of outputs to benefits via utilisation must be a key element of project design.

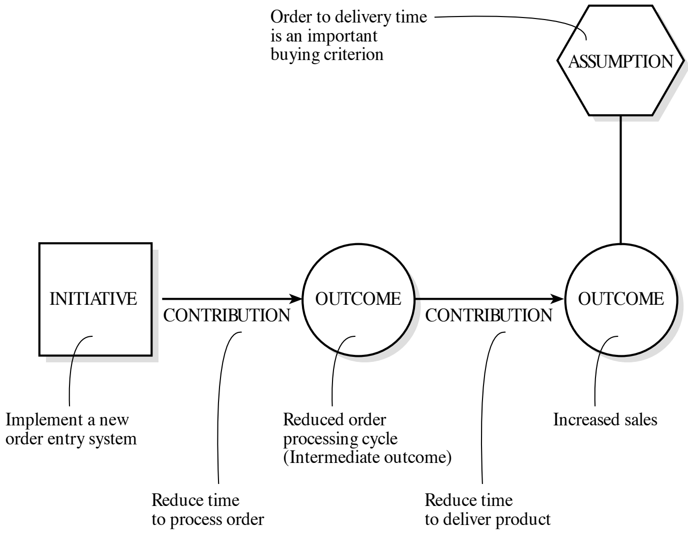
Figure 2-9. ITO Process for appropriating the benefits of a project *(Smyrk 1995)*



Thorp (2003) suggest that benefits don't just happen and that they flow and evolve over time as people learn to utilise the outputs. Thorp (2003) proposed that benefits realisation was a continuous process that needed to be managed as a process and likened benefits realisation to a corporate earnings forecasts, in that that they fluctuate over time.

Thorp (2003) advocated program management over stand-alone project management, effectively a portfolio approach that moved away from a project completion focus to blended investment programs that focused on alignment between outcomes and business objectives. Thorp (2003) proposed modelling linkages between initiatives and outcomes using results chains as road maps (see figure 2-10).

Figure 2-10. Illustration of a simple results chain (Thorp 2003)



Ward, Taylor and Bond (1996), Smyrk (1995) and Thorp (2003) support the notion of a benefits realisation inclusion in traditional project management methods, but propose it expand beyond design-develop-test-deliver and into to harvesting the end results.

Looking beyond the organisational IT implementation perspectives there are also several methods and approaches associated with new product and business development that have been embraced by IT practitioners. Where project management, software development and change management methodologies all play a valuable role in implementation, new product and business development frameworks notionally provide an overarching macro-based approach for the implementation or commercialisation of innovations (Cooper 2008).

Notable amongst these methods is the Lean Start-up Methodology (Reis 2011), which anecdotally has had widespread adoption in technology start-up communities such as Silicon Valley in the United States.

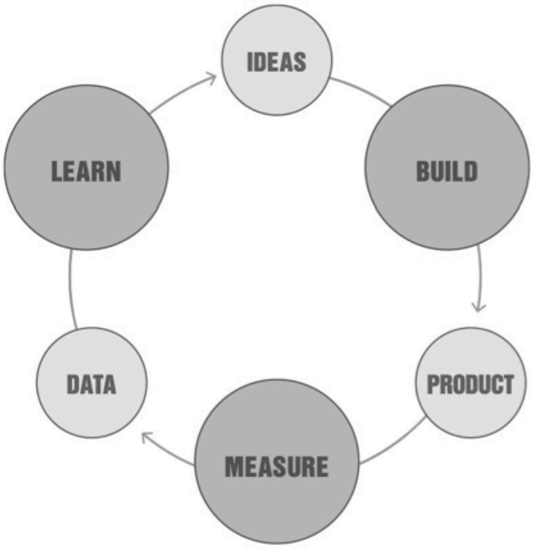
The Lean Start-up Methodology is a framework for "managing projects in markets of extreme uncertainty" i.e. start-ups (Warberg & Thorup 2016). Like Lean Software Development, Lean Start-up Methodology has its roots in the lean manufacturing movement pioneered by Toyota as part of the Toyota production system. The methodology described by Reis (2011) is a practical elaboration of an alternative business development model proposed by Blank (2006).

Blank (2006) originally described a “Customer Development Model” designed to complement the traditional product development model that had followed a staged process through concept, product development, testing and launch. The main tenet of Blank’s model was to focus on understanding customer problems and needs, and validating a business model that can sustainably create customers and build a business (Blank 2006, p. 16). Based on personal experiences within the software industry Reis (2011) argued that a new definition of value was required for startups. In contrast to defining customer value for a traditional manufacturer, value for a startup’s customer was often uncertain. Reis (2011) suggests that value for a startup is working out what the customer values, and that waste (in the lean tradition) was anything that did not help work this out (at least in the early stages of a startup).

In response to the value problem Reis (2011) proposes that validated learning through scientific method is the best way to answer key customer value questions, such as “should a product be built?” and “can we build a sustainable business around this set of products and services?” Hence the Lean Start-up Methodology advocates observation over asking direct questions of the customer and proposes testing customer value hypothesis through experiments backed by rigorous data collection and actionable metrics, the latter Reis (2011) defines as “innovation accounting”.

Central to the Lean Start-up Methodology is an alternative customer discovery and validation model that involves a series of experiments about how to build a sustainable product or business. Reis (2011) describes this model as a feedback loop that transitions through a cycle of build, measure and learn.

Figure 2-11. Build-measure-learn feedback loop *(Reis 2011, p. 81)*



Reis (2011) further suggests that the key objective for a startup is to minimise the time (waste) spent cycling through this loop, introducing the notion of a minimum viable product (MVP) that represents one full cycle through the loop. The MVP subsequently becomes the baseline business plan to be tuned or tweaked to a point that it is preserved or changed (pivoted) to define a new product strategy.

Despite its popularity within the information technology start-up community there has been limited empirical testing into the effectiveness of the Lean Start-up Methodology leaving it open to various levels of critique. Examples include:

- Questions about the true scope of its applied use and adoption.
- Its application beyond the start-up context, in particular when comparing the Lean Start-up Methodology to theory associated with design thinking (Müller & Thoring 2012).
- How the quest for a minimum viable product may have implications for quality and a tendency to disregard investment in IT architecture (Hussein 2015; Sharkey 2013).
- How seeking to eliminate uncertainty in new product development may have implications for creativity and innovation (Hussein 2015; Warberg & Thorup 2016).

2.3.4 Sources of knowledge for IT/IS implementation

There is a wide variety of knowledge utilised in IT/IS implementation. A key factor in the success of IT/IS implementation initiatives is that adequate knowledge is directed towards the development and implementation effort (Kwon & Zmud 1987).

Two primary sources of knowledge that are described in the IT/IS implementation literature are IT technical knowledge (technological knowledge) and user/customer requirements knowledge. Technological knowledge for IT/IS implementation pertains to the knowledge held by individuals and managed as resources by organisations that relate to the design, development, implementation and management of IT/IS. User/customer requirements knowledge is obtained through a process of designer-user interaction (Newman & Robey 1992). Kwon and Zmud (1987) argues that findings within the IT/IS implementation literature suggest that the likelihood of IS implementation success increases with the quality of designer-user interaction, that being the desirability of designer-user interaction and the cognitive functioning of users and designers.

Organisations access and manage various sources of knowledge through internal staffing or collaboration and/or partnership with external individuals and organisations (Lee, J-N 2001). Also prevalent within the IT/IS sector is the availability of open sources of knowledge (Hippel & Krogh 2003). Wang and Ramiller (2009) also emphasise the role of acquiring new or modifying and reinforcing existing IT knowledge through community interaction.

Segelod and Jordan (2004) explore the importance of external knowledge acquisition within the software development sector ranking the importance of various external knowledge linkages. This research found that without comparison, external linkages with customers were the most important in terms of overall knowledge acquisition. This research also found that 'linkages to suppliers, competitors, hardware manufacturers, fairs/conferences, technical consultants, the press, affiliated companies, and market consultants, are all considered more important, than those formed with universities, other research institutes, patent offices, or financial promoters' (Segelod & Jordan 2004, p. 239).

Lee, J-N (2001) confirms that knowledge sharing is also critical predictor for outsourcing success and that partnership quality is an important intervening factor between knowledge sharing and outsourcing success.

Indirectly related to the literature concerning IT/IS implementation is the application of knowledge management processes and systems within the tradition of the knowledge based view of the firm (KBV). Nonaka (2005, p. 9) argues that 'firms exist because markets are incapable of coordinating the knowledge of individual specialists' and that this is the role of management within a firm. Nonaka (2008) later suggests that the creation of new knowledge depends on capturing tacit knowledge from employees or partners, and that this often involves 'subjective insights, intuitions, and hunches of individual employees' to be made available for testing and use by the organisation as a whole. The core assumptions of KBV are that (1) organisations apply knowledge to the production of good and services, (2) knowledge is created and held by individuals, not organisations, and (3) knowledge is the most strategically important of an organisation's resources (Grant 1996).

The application of KBV to IS/IT implementation is arguably significant and recognised in the number of studies that integrate its use into development, implementation and management of IT/IS. For example: Pavlou et al. (2005) created a KBV perspective on the organisational value of IT; Teigland and Wasko (2003, p. 261) explored knowledge acquisition management strategies in IT/IS development that found evidence that for organisations to support 'boundary spanning and knowledge sourcing' from both internal and external sources; Owen, Connor and Linger (2011) proposes the use of knowledge management systems to support the project management of IS development projects; and Kearns and Sabherwal (2006) suggests that knowledge flows through the integration of business planning and IT planning can be influential for IT/IS implementation success on a strategic level.

Of particular significance for IS/IT implementation is the discussion of initiated by Leonard-Barton (1992) that views firm resources and capabilities as knowledge sets. This research suggests that an additional source of knowledge available for IS/IT implementation would be the tacit knowledge embedded into systems, procedures and tools developed over time by members of an organisation. The open source software movement typifies this concept from a software perspective, but the notion is equally prevalent for the internal and external development of methods and tools for development and implementation e.g. systems development and project management methodologies. Similarly (Baetjer 1997, p. 8) describes software in itself as ‘the embedded knowledge of a productive process’.

2.3.5 The producers and users of IT/IS

It is common to classify the actors operating with the IT/IS domain as either a producer or a user. The IT-producer sector comprises organisations or firms that primarily produce information technology goods or services. This would typically include hardware and software manufacturers, value added service providers along with network and telecommunications service providers. The sector is also referred to as the information communications and technology (IT) sector and is seen to overlap into areas of information content production such as online media and entertainment (OECD 2009).

Not all IT producers are the same and it is possible to break down the producers into three quite different classes:

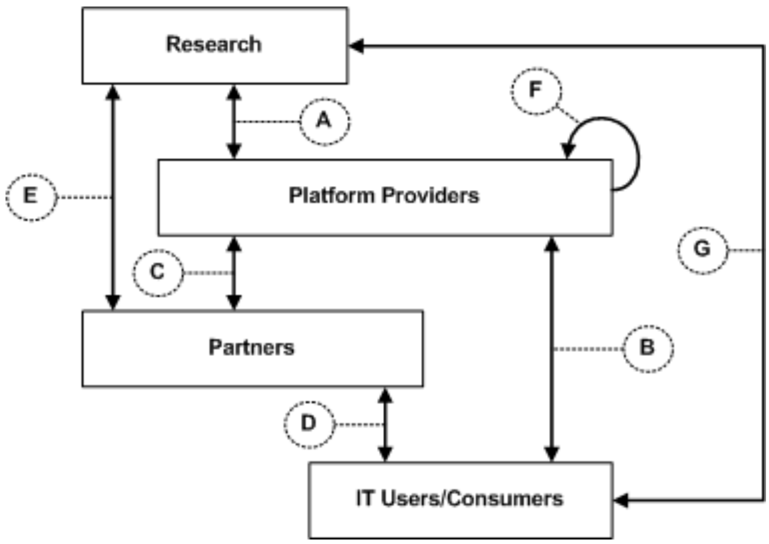
- “Big IT” – well established IT producers and the custodians of successful platforms and many mainstream applications.
- Value Adding Intermediaries – IT producers who modifying or improve applications and platforms.
- Experimental Start-ups – IT producers working with new concepts and technologies.

The IT user sector comprises organisations or firms that utilise information technology as part of their operations. Whilst they do not produce information technology goods and services as their primary activity, the production or development of information technology goods and services is certainly not precluded. It has been demonstrated that great proportion of IT development occurs outside of the IT-producing sector within the IT-user sector (Smith 2002, 2005; Smith, O'Brien & Jerrim 2007). Occasionally new IT producers emerge from innovations initially undertaken by IT-user sector businesses.

Like other technologies, information technology also appears to develop and progress through a system of producers, researchers, consumers, competitors and value added manufacturers (Iansiti & Richards 2005).

Iansiti & Richards (2005) make a distinction between two methods of interaction within an 'information technology ecosystem', where actors interact by providing applications and/or platforms. Applications are defined as products or services that solve specific problems or perform specific functions. Platforms on the other hand, are defined as a set of tools or components that provide the building blocks for applications. Whilst Iansiti & Richards (2005) distinction is very much oriented towards software development ecosystems, the concepts work equally as well for hardware, communications and services. Figure 2-11 provides a high level overview of the actors in an information technology ecosystem, although we should acknowledge that like the user-producer phenomena, the boundaries depicted between the actors in this ecosystem are sometimes not so definitive.

Figure 2-12. Actors and interactions in an information technology ecosystem, adapted from Iansiti & Richards (2005)



Platform providers are those who develop and provide the systems from which other systems and technologies are based. Iansiti & Richards (2005) place platform providers at the heart of the information technology ecosystem, suggesting they are critical for innovation and productivity. Since the 1980s a number of large corporations emerged as a result of providing IT platforms. Examples include Intel, Microsoft, Apple, IBM, Oracle, SAP, Google. "Big IT" have often made their fortunes in conjunction with the successful development and diffusion of an information technology platform. Some, like SAP, started out as application providers, whilst others like Intel, provided complementary components for platform providers. The platform providers interact with both partners (C) and users/consumers (B).

Partners are those who develop applications for and systems for users and consumers (D). The applications will be based on particular platforms (C). Examples of which include software developed for the Microsoft Windows platforms or “apps” developed for Apple smart phones and tablets. Partners may also provide components and services for the production of platforms (C). Partners often collaborate with the platform providers to provide functional enhancements (C again) or in some instances the synergy of their work may result in their acquisition or merger with the platform provider. For example, Google’s acquisition and integration of Postini into its web email platform. Postini was an email security and archiving service acquired by Google in 2007 (Girouard 2007). Google has since integrated the services into its email and application products.

IT Users/Consumers are those who use and consume the applications, products and services (D). In many cases users will develop their own applications and services using platforms provided directly by the platform providers (B). It is also not inconceivable for IT Users/Consumers to engage with research (G). They have also been shown to participate in new product development activities (Von Hippel 1986) with both platform providers and partners (B) and (D).

Finally *research* bodies and knowledge networks provide access to scientific and technical knowledge. Research tends to interact with all actors (A), (E) and (G), acknowledging that the actors may or are in many cases situated within the organised control of other actors. A somewhat classic example of the role of research in the information technology ecosystem would be the Palo Alto Research Centre (PARC). Founded by Xerox in 1970 PARC played an instrumental role in the invention of a number of foundational information technologies, with research in the areas of laser printing, graphical user interfaces, networking technologies such as fibre optics and Ethernet, ubiquitous computing (notebooks and tablets), object oriented programming and many more. PARC’s research appears in many mainstream information technology products such as those used by Apple, Microsoft, HP, etc.(Xerox PARC 2012).

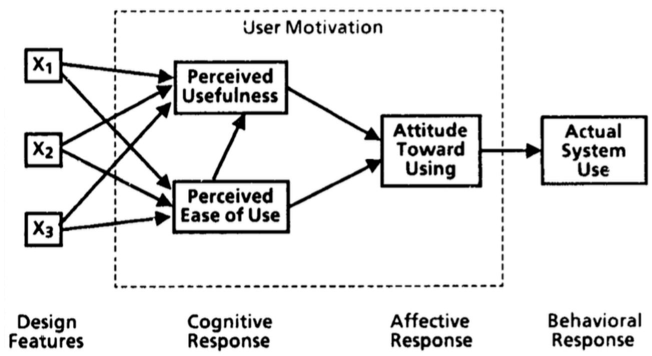
The general-purpose nature of information technology sees it utilised across many industries and domains and observations from Iansiti & Richards (2005) suggest exploring IT development, implementation and use within the IT-producing sector and the IT-user sectors.

2.3.6 IT innovation, diffusion and adoption

There is a considerable body of IT/IS literature that extends the IT/IS implementation literature towards contemporary innovation theory. A great proportion of this research has been undertaken using a diffusion-based perspective (Fichman 2004; Williams et al. 2009). Within the diffusion and adoption perspective various theories have been used to explain individual and organisational adoption of information technology innovations.

A number of researchers Davis (1985), Davis, Bagozzi and Warshaw (1989) and Venkatesh et al. (2003) have focused on diffusion and adoption at the level of the individual. This research has introduced several behavioural models for user acceptance based on the Theory of Reasoned Action (Ajzen & Fishbein 1973). Davis (1985) for example introduced the Technology Acceptance Model (TAM) that proposed individual adoption and use of information technology was linked to perceived usefulness and perceived ease of use, whereby there was also an intermediary link between the intention to use and actual system use, as shown in figure 2-12.

Figure 2-13. Davis (1985) original Technology Acceptance Model.



The TAM and other user acceptance based models have been subsequently tested, extended and integrated by the research community (Wixom & Todd 2005). Researchers have simplified TAM by removing the attitude construct (Furneaux 2014).

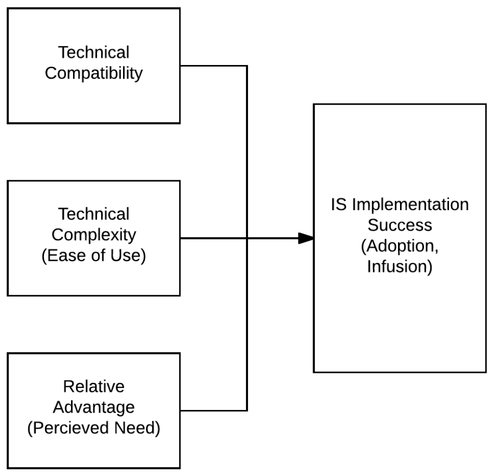
Other researchers have focused on organisational diffusion and adoption. Rogers (1983) diffusion of innovations (DOI) framework has been influential in this thinking. Moore and Benbasat (1991) introduced DOI into the IS context to explore perceptions of technology by potential adopters. This research used Rogers (1983) five attributes for the adoption of innovations – relative advantage, compatibility, complexity, observability and trialability, and added image and voluntariness from the extant IS literature, as shown in table 2-2.

Table 2-3. Seven attributes influencing IS adoption *(Moore & Benbasat 1991)*

Attribute	**Description**
Relative Advantage	The degree to which an innovation is perceived as being better than its precursor.
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters
Complexity	The degree to which an innovation is perceived as being difficult to use.
Observability	The degree to which the results of an innovation are observable to others
Trialability	The degree to which an innovation may be experimented with before adoption.
Image	The degree to which use of an innovation is perceived to enhance one's image or status in one's social system
Voluntariness	The degree to which use of the innovation is perceived as being voluntary, or of free will

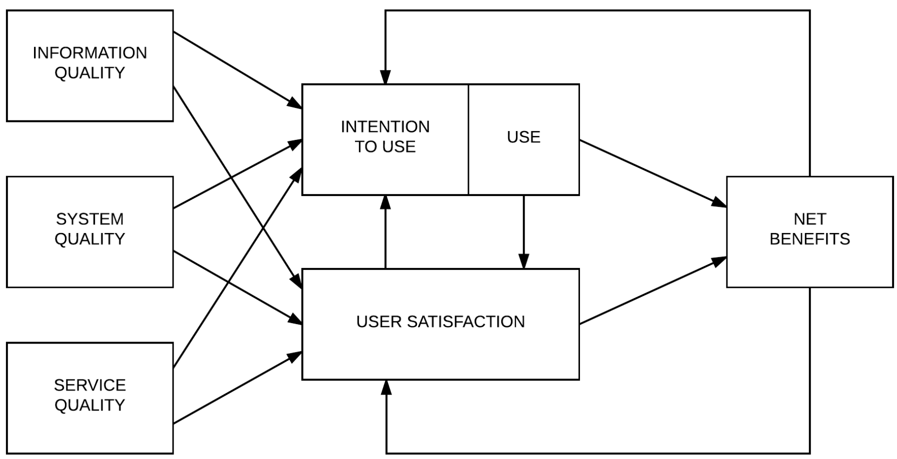
Research has progressed along this stream with notable contributions from Cooper and Zmud (1990), Crum, Premkumar and Ramamurthy (1996), Agarwal and Prasad (1997), Bradford and Florin (2003) and Mustonen-Ollila and Lyytinen (2003). Furneaux (2014) provides a generalised model (figure 2-13) of this progress that argues technical compatibility, technical complexity (ease of use), and relative advantage (perceived need) are consistently found to be the primary antecedents for the adoption of IS innovations.

Figure 2-14. Furneaux (2014) IS diffusion variance model



In a similar manner Delone and McLean (1992) introduced a model of IT/IS implementation success that agued information quality and system quality influenced user satisfaction and intention to use that inturn influenced organisational outcomes. Later extensions of this theory by the IS research community provided additional feedback paths relating to use and user satisfaction derived from benefit realisation. An updated model is provided in Delone and McLean (2002) and illustrated in figure 2-14.

Figure 2-15. Delone and McLean (2002) IS success model



Delone and McLean (2002) updated model proposes that information systems can be evaluated in terms of information quality, system quality and service quality. These quality attributes then impact the use or intention to use and consequently user satisfaction. Using the system will realise certain benefits and these benefits will, in turn, feedback and influence user satisfaction and the further the use of the system.

A number of concerns have been expressed in relation to the status of the IT/IS diffusion and adoption literature (Bagozzi 2007; Benbasat & Barki 2007; Fichman 2004; Lucas, Swanson & Zmud 2008; Lyytinen & Damsgaard 2001). Lucas, Swanson and Zmud (2008) provide four notable criticisms – (1) the fragmentation of theoretical models; (2) a lack of insight around the implementation process; (3) a heavy focus on factors associated with individual adoption and acceptance, overlooking organisation factors; and (4) ignoring the nature of the information technology artefact and where it is introduced (the innovation context).

Irrespective of the issues and critique of the existing IT/IS diffusion and adoption literature, diffusion and adoption are important elements of innovation theory and important for understanding IT Innovation (Ruttan 1996). This body of knowledge describes a significant proportion of what is currently known about IT innovation. However diffusion cannot progress without invention (Hall 2005) and exclusively focusing on diffusion and adoption (or implementation) problems in all probability overlooks important elements of IT innovation. For example: information technology design; the acquisition knowledge for information technology design; and possibly the role of collaboration between organisations, institutions, communities and individuals.

Acknowledging these concerns several researchers turned to organisational change management and innovation theory in an attempt to consolidate or unify the fragmented theoretical setting (Carlo, Lyytinen & Rose 2011; Cooper & Zmud 1990; Kwon & Zmud 1987; Lyytinen & Rose 2003; Swanson 1994).

Kwon and Zmud (1987) provide a comprehensive review of the IS implementation literature and identify five core research themes present in the literature of the time: (1) research that focuses on factors most related to IS implementation success or failure; (2) mutual understanding research that focuses on the quality designer-user interaction; (3) process oriented research that looks at the generic stages or sequence of IS implementation; (4) research concerning the political factors that facilitate promotion, engagement or resistance with respect to IS implementation; and (5) research that examines the findings of prior research to identify risks associated with IS implementation. Following this examination of the literature. Kwon and Zmud (1987, p. 241) argue that most IS implementation studies focus on a single theme and that they are focused on ‘small pieces of the MIS implementation puzzle, without considering larger issues’ Kwon and Zmud (1987) ultimately resolve that the IS implementation research had become fragmented and lacked ‘a common perspective’.

To address this issue Kwon and Zmud (1987) propose that a process based perspective of IS implementation be combined with organisational innovation theory to provide a core construct that viewed IS implementation as a technological innovation. The resulting framework (figure 2-15) overlays a diffusion-based model of IS implementation stages derived from IS implementation theory, with an adaption of Leavitt (1965) critical factors for change model[1] (table 2-3). Influential IS implementation factors were then mapped to the critical change factors and reviewed in the context each stage of IS implementation.

Figure 2-16. IS implementation process (Kwon & Zmud 1987)

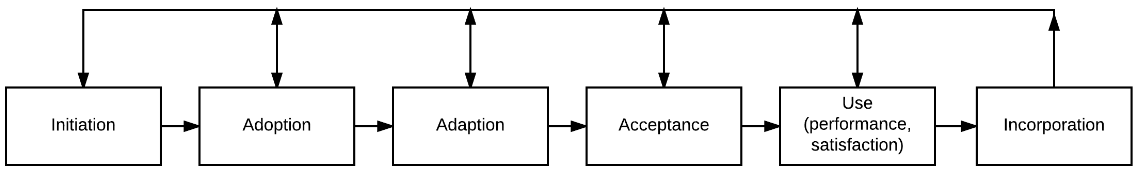


Table 2-4. Influential IS implementation factors (Kwon & Zmud 1987)

Individual (User)	Structure (Organisation)	Task	Technology	Environment
Job tenure	Specialisation	Task uncertainty	Compatibility	Heterogeneity
Cosmopolitan	Centralisation	Autonomy	Relative advantage	Uncertainty
Education	Formalisation	Responsibility	Complexity	Competition
Role envolvment	Informal network	Variety		Concentration
Attitude toward change		Identity Feedback		Organisational dependence

[1] Kwon and Zmud (1987) added an environmental factor from the extant organisational change literature.

Kwon and Zmud (1987) successfully introduced an alternative framework that combined a broad family of IS implementation research. It was also arguably the first to look towards innovation theory for guidance. Since its introduction the IS implementation literature has progressed significantly with many of the gaps identified in Kwon and Zmud (1987) arguably filled. However the resulting framework is still unequivocally diffusion driven, missing important elements of development and design that are synonymous with IT innovation. Furthermore, by virtue of its timing the framework was also unable to incorporate contemporary notions of innovation that are prevalent in the current literature, such as dynamic models of change and permeable organisational boundaries and systems.

Swanson (1994) approaches the IT/IS implementation diffusion and adoption phenomena from an organisational innovation perspective and develops a model and taxonomy for IS innovation. Swanson (1994) is one of a handful of studies that touches on a discrete definition for IT/IS innovation, describing it as 'the organisational application of information technology … that may involve a new IS product or service, a new IS work technology or a new IS administrative arrangement' (Swanson 1994, p. 1069).

The Swanson (1994) tri-core model is an adaption of earlier work by Daft (1978) that describes two distinctly different forms or cores of innovation found within organisations – technical innovations and administrative innovations. Technical innovations relate to products, services and process technology innovations, whereas administrative innovations involve organisational structure and administrative processes, indirectly related to the activities of an organization and directly related to its management (Damanpour 1991). Daft (1978) argues that each innovation core involves different and possibly opposing factors and decision-making processes. Swanson (1994) argues that the Daft (1978) dual-core model of innovations is inadequate for studying IS innovation because IS innovations can span both cores and that there are distinct innovations associated with organisational IS functions. Thus Swanson (1994) introduces a third core to address this gap. An important additional contribution associated with Swanson (1994) tri-core model is the development of an IS innovation taxonomy that is summarised in table 2-4 using in part the descriptions provided in Grover, Fiedler and Teng (1997).

Table 2-5. Swanson (1994) IS innovation taxonomy taken from Grover, Fiedler and Teng (1997).

Subtype	**Innovation Core**	**Description**
	TYPE 1 INNOVATION	
Type 1a	IS Administration Process Innovation	Innovation that focuses on the management and administrative support for IS work.
Type 1b	IS Technological Process Innovation	Innovation that focuses on the technical tasks i.e. changes in the nature of IS work.
	TYPE 2 INNOVATION	
Type 2	IS Product and Business Administrative Process Innovation	Innovation involving IS products and services that affect the administrative core of the host organisation.
	TYPE 3 INNOVATION	
Type 3a	IS Product and Business Technological Process Innovation	Innovation involving IS products and services that affect the core work processes of the host organisation.
Type 3b	IS Product and Business Product Innovation	Innovation involving IS products and services that inherent to or imbedded in the host organisations product and services.
Type 3c	IS Product and Business Integration Innovation	Innovation involving IS products and services that affect the integration or coordination of the host organisation with its suppliers, distributors and customers.

The tri-core model (Swanson 1994) emerged during a time when innovation theory was developing new insights innovation within organisations. The notion of organisational innovation used by Daft (1978) and Swanson (1994) is somewhat broader than currently applied in the innovation literature. For example the Oslo Manual (OECD/Eurostat 2005) defines organisational innovation as ‘the implementation of a new organisational method in the firm’s business practices, workplace organisation or external relations’ its arguably referring to administrative innovations, where technical innovations are covered by product, process and marketing innovations. Whilst the tri-core model is still focused on innovation diffusion and adoption, Swanson (1994) represents an initial starting point in recognising the role innovation theory can play for improving understandings of IT innovation.

A number of empirical studies of have since progressed using Swanson (1994) organisational innovation perspective (Carlo, Lyytinen & Rose 2011; Grover, Fiedler & Teng 1997; Wang & Ramiller 2009).

Carlo, Lyytinen and Rose (2011) describe two categories for classifying IT innovations. The first is based on content or 'what one is innovating with'. The other based on the nature or radicalness of innovation, which is linked to the originality and uniqueness (novelty) of innovation outcomes. The content category essentially updates and simplifies the tri-core model (Swanson 1994) based on the earlier work of Lyytinen and Rose (2003), reflecting changes in role of IT in the organisational context and acknowledging contemporary classifications innovation.

Table 2-6. IT innovation areas (Carlo, Lyytinen & Rose 2011)

Innovation Area	Description
Base IT innovations	Changes in the core systems, platforms and infrastructure.
Process innovations	Changes in technical and supporting administrative processes. For example changes in development tools, methods, teams and their structure.
Service innovations	The development of new technical and business solutions for customers and users

The nature-based category of IT innovation introduces some of the dynamic and technological change based perspectives from innovation theory. This category proposes that IT innovations lie on a scale ranging from incremental to radical, and that the basis for classification is how the innovator perceives the innovation in terms of its originality and uniqueness (novelty).

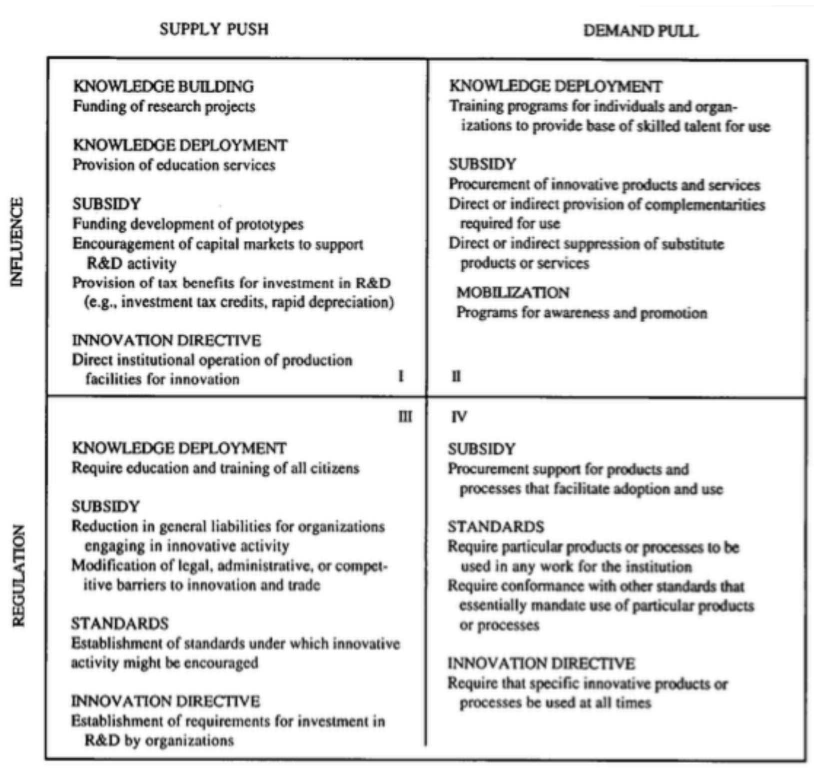
To this end (Carlo, Lyytinen & Rose 2011, p. 91) incorporate disruptive innovation theory (Christensen & Raynor 2003) into the IT innovation thinking, describing disruptive IT innovation as IT innovation where the 'effects are transformative and path-breaking in that they start to strongly influence the future IT innovation direction'. Important in the context of Carlo, Lyytinen and Rose (2011) is the notion that disruptive IT innovations can emerge from radical IT innovations when radical innovation occur across all three types of IT innovation content. Carlo, Lyytinen and Rose (2011) tested the effects of radical IT innovation across the different types and found that base IT innovation influenced service innovation; and base IT innovation and service innovation together influenced process innovation.

Consistent with the fragmentation of IS implementation research, several researchers have taken up arrange of theoretical perspectives that also have direct or indirect thinks with innovation theory.

King et al. (1994) for example discuss the importance of institutions in shaping information technology innovation. King et al. (1994) defines institutions as “any standing social entity that exerts influence and regulation over other social entities”. Thus the definition includes but is not limited to government, research and industry based entities. A key contribution of King et al. (1994) is to describe a model institutional action in the terms of the potential institutional action that might be exerted in the context of technological change. Institutional action in placed in the context of influence and regulation, where technological change is placed in the context of supply-push and demand-pull. The model is presented as matrix per

Figure 2-17 below.

Figure 2-17. *The dimensions of institutional intervention (King et al. 1994).*



King et al. (1994) also describe in additional detail, six different forms of institutional action:

- Knowledge Building – where institutions provide "the base of scientific and technical knowledge required to produce and exploit innovations".
- Knowledge Deployment – where institutions facilitate the diffusion of new knowledge.
- Subsidies – where an institution utilises its resources to assist entrepreneurs or users to reduce their exposure to risk in in the context of adoption or innovation e.g. to provide grants for entrepreneurs.
- Mobilisation – where institutions encourage stakeholders "to think in a particular way with respect to an innovation".
- Standard Setting – where an institution constrains the options of stakeholders to align innovation with broader objectives.
- Innovation Directives – where an institution commands the production or use of an innovation, or an activity that will facilitate such.

Markus (2004) suggests that IT driven organisational change differs from typical IT projects and organisational change programs and that it requires a different approach. Markus (2004) cites two reasons for this (i) the emergence of problems during typically long sequential process of change; and (ii) projects not typically focusing on important complementary organisational changes to facilitate IT adoption. Markus (2004) emphasises the importance of the alignment between information technology and organisational change and argues that a combined IT project management and organisational change approach can be made to work using an iterative, incremental approach.

Clemons & Row (1991) draw upon the management science literature to further the discussion of how the benefits associated with innovative application of information technology can be exploited to gain competitive advantage. There is also a significant body of work that explores process innovation. This initial work emerged from Davenport & Short (1990), and Hammer (1990). It emphasised the complementary potential of information technology to facilitate revolutionary organisational innovation (business process reengineering). Though somewhat controversial at a practical level, these and similar studies were precursors to information systems research being established in the fields of business process analysis, design and management.

2.4 Innovation theory

2.4.1 Introduction

Theory concerning innovation is routinely traced back to the work of Austrian economist/social scientist Joseph Schumpeter (1934; 1939; 1942; 1947), who viewed innovation as the driving force for economic and social change. Schumpeter's ideas (ibid) were predominately focused on long run economic growth/performance and the role of the entrepreneur, uncertainty and the dynamic nature of change (Fagerberg & Verspagen 2009).

Schumpeter (1934) proposed that it was possible for an economy to change without the influence of external factors and that the source of these changes are new combinations of capital and labour giving rise to (1) the creation of a new good or new quality of good; (2) the creation of a new method of production; (3) the opening of a new market; (4) the capture of a new source of supply; and/or (5) a new organization of industry. For a variety of academic reasons Schumpeter's views were widely ignored in favour of neoclassical growth theories until a resurgence of interest in technology research and development after World War II.

Where Schumpeter (1939) emphasised radical or discontinuous change, others such as Rosenberg (1976), and Freeman and Soete (1997) looked at incremental, marginal and continuous change. Lundvall (1992) and Fagerberg (2005) suggest the cumulative impact of incremental change is highly significant and that ignoring it lead may lead to a biased view of long run economic change. Conceivably most change is in fact continuous and that most radical change actually happens through small incremental innovation over longer timeframes.

2.4.2 What is innovation?

There are a wide range and variety of definitions for innovation and it is regularly discussed within the economics and management science literature (Backhouse 2014). Broadly speaking innovation is the act of putting new ideas and designs into practice. The term innovation is also used interchangeably to describe both the process of introducing something new and the outcome of introducing something new (an innovation).

Innovation is a key component of technological change. Schumpeter (1934) described technological change as process where new technology enters the marketplace through three stages of development (1) invention – the act of conceptualising new ideas or designs; (2) innovation – putting ideas and designs into practice; and (3) diffusion – the broader use and adoption of the innovation (Jaffe, Newell & Stavins 2002). Contemporary views of innovation see it as an emergent process where it is difficult or even inappropriate to separate the act of invention, innovation and diffusion from the overall process of technological change (Freeman 1991; Rosenberg 1976; Ruttan 1959). Recent definitions of innovation acknowledge the continuous nature of technological change tend to encapsulate all three stages over indefinite timeframes to provide a more inclusive, albeit broader definition of innovation (Kline & Rosenberg 1986; Rosenberg 1976).

A precise definition for innovation is provided in The Oslo Manual (OECD/Eurostat 2005, p. 46). This definition draws on the innovation literature and describes innovation as 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations'.

2.4.2.1 Innovation and technological change

Technological change is a process whereby scientific and technical knowledge are used to create or improve products, processes, marketing methods or new sources of supply that are then spread throughout an economy and/or society in general. Technological change can be characterised by two different but complementary types of change. Discontinuous, radical (unpredictable) change driven by fundamental scientific developments and the creative leadership of entrepreneurs; and continuous, incremental change where producers and users improve and fine tune innovations throughout the technology lifecycle (Freeman 1991).

Early research concerning technological change was heavily influenced by Schumpeter's work on entrepreneurism and business cycles and tended to view technological change as linear or staged process. Such models of change would follow a sequence of invention, innovation and diffusion with sharp distinctions between each sequence. Schumpeter's work was predominately focused on discontinuous change and major innovations and it largely ignored the role of invention and diffusion.

Ruttan (1959) and Rosenberg (1976) were highly critical of the sequential disjunction between invention, innovation and diffusion (Freeman 1991). Rosenberg (1976, p. 77) reflects on this early view of technological change in the context of innovation suggesting such a distinction only 'served to obscure rather than to illuminate to the process of innovation'. Rosenberg (1976, p. 77) goes on to argue that the incumbent view was 'overtly focused on major innovations', 'neglected the role of continuous incremental improvements', 'attached excessive importance to the role of scientific knowledge at the expense of engineering and other 'lower forms' of knowledge' and 'gave excessive significance to the early stages of invention and neglected crucial later stages'. Research latter emerged which highlighted issues at each end of the sequence. Arrow (1962) for example developed the concept of learning by doing, suggesting that workers often implemented improvements to products and processes by virtue of experience and practice. Von Hippel (1976, 1986) highlighted the role of users in developing and refining products and services within diffusion settings, whilst Lundvall (1992) suggested such activity was part of a broader flow of information and technology between networks of people participating in an innovation system.

These and similar studies grounded the theory that a large portion of technological progress was due to incremental change and that activity normally associated with the innovation sub-process often spanned across the invention and diffusion processes.

Kline & Rosenberg (1986) provide an alternative and often cited high level model which illustrates key relationships between research, invention, innovation and production. Their chain-linked model describes a central chain-of-innovation encompassing design, development, production and marketing with a series of iterative feedback style links between the central innovation chain processes. The model also includes several alternative paths to represent the flow of information and collaboration with the science and research domain. The science and research domain is placed alongside the central chain of innovation in acknowledgement that science and research played an extended supporting role in technological innovation.

Whilst a range of alternative non-linear models have been proposed, the chain-linked model is possibly the most cited. Kline and Rosenberg (1986, p. 294) state the limitations of the model as being high level and 'omitting the details of the rich variety inherent in the totality of innovations processes in current times'. Innovation and innovation activity are central themes in both types of technological change. The chain-linked model illustrates the importance of innovation and innovation activity and serves to support the broader definition innovation as encapsulating invention and diffusion.

2.4.2.2 Different types of innovation

There are many different innovation typologies defined and described throughout the innovation literature (Garcia & Calantone 2002). Schumpeter (1934) originally described five types of innovation – the creation of a new good (product), creation of a new method of production (process), opening of a new market, capturing a new source of supply, and a new organisation of industry.

The Oslo Manual (OECD/Eurostat 2005) refines and consolidates the classification scheme for the purpose of measuring innovation, defining four types of innovation – product innovation, process innovation, marketing innovation and organisational innovation. The characteristics associated with each type are outlined in Table 2-7

Table 2-7. Type of innovation (OECD/Eurostat 2005).

Classification	**Description of Innovation**
Product Innovation	The introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.
Process Innovation	The implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
Marketing Innovation	The implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
Organisational Innovation	The implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

Another commonly used typology is to classify innovation in terms of its novelty and impact upon established capabilities (Henderson & Clark 1990). Whilst there are variations within this approach innovations under this scheme tend to be classified along the lines of Freeman and Soete (1997) technological change categories, using the terminology radical and incremental innovation. Incremental innovations are innovations that refine and improve an existing design, reinforcing existing capabilities within industry or an organisation. Radical innovations on the other hand, have a high degree of novelty and introduce new designs and approaches. Radical innovations will often require new technical and problem solving skills (Henderson & Clark 1990; Norman & Verganti 2014). However is has been observed that some innovations that involve fairly modest changes to existing designs can have significant consequences (Henderson & Clark 1990).

Christensen (1997) describes a disruptive model for innovation that distinguishes between two types innovation – sustaining and disruptive. The Christensen (1997) typology is similar to notions of incremental and radical innovation but alternatively focused on market impacts. Sustaining innovations are consequently defined as innovations that improve the performance of a product or service along various performance dimensions that are valued by existing customers and markets. Disruptive innovations are defined as variations to existing designs that essentially underperform existing products and services but provide other features that are valued by some customers and potentially new customers (Yu & Hang 2010).

Christensen (1997) initial work was focused on technology innovation; in fact the term used was disruptive technology as opposed to disruptive innovation. The notion of disruptive technology and disruptive innovation is pervasive within the IT/IS domain and especially in IT market research, thus it merits discussion in the context of this study.

The model of disruptive innovation theory has been subjected to significant criticism within the innovation and economics literature. In particular it is argued that disruptive innovation in itself is an incomplete theory that does not fully explain key elements of radical innovation (Utterback & Acee 2005; Yu & Hang 2010). Others argue that disruptive innovation theory has been misunderstood and over applied (Christensen 1997; Lepore 2014).

Garcia and Calantone (2002) see novelty and impact operating at both the market and at the technological level. Garcia and Calantone (2002) propose that radical innovations are those that create new markets or technological discontinuities, where incremental innovations are those that introduce improvements into existing technologies used in existing markets.

2.4.3 Important characteristics and dimensions of innovation

There is a significant body of research that attempts to explain innovation and its various dimensions and characteristics. Fagerberg (2005) and Smith (2007) provide a concise account of what has been learned about innovation from this research.

2.4.3.1 Innovation is pervasive.

There is a broad body of empirical research which demonstrates that innovation occurs across different industries, regions and sectors and that it is not exclusively restricted to high tech industries (ABS 2014; Hirsch-Kreinsen et al. 2003; Smith 2000; Smith, O'Brien & Jerrim 2007). Whilst innovation is pervasive it is not homogeneous and there are several sources of variety in innovation activity. Evangelista and Mastrostefano (2006) argue that the main sources of sources of variety are sectorial, national, firm size and, firm specific.

Innovation is different across different sectors. The amount and type resources used in innovation activity vary from industry to industry. Pavitt (1984) provides an overview of sectorial-based patterns of innovation that exemplifies the differences.

Dosi (1988) suggests that innovation is largely driven by differences in national technological competencies. At a national level technological diffusion is influenced by economic, social and institutional factors. However the global exploitation of technology, global collaboration, and global generation (across national boundaries) also facilitates new forms and varieties of innovation (Archibugi & Planta 1996).

Firm size has also been shown to affect the probability of systematic innovation. Different sized firms often take a different approach or strategy with respect to innovation (Evangelista & Mastrostefano 2006). Schumpeter (1934) initially focused on small firms and entrepreneurs as being the primary the source of innovation, however later (Schumpeter 1942) revised this view to acknowledge the relevance of larger firms in systematic innovation (Malerba & Orsenigo 1995).

Firm specific factors have also been shown to influence the variety of innovation. Because knowledge assets and technological competencies are unevenly distributed amongst firms, different varieties of innovation occur. The impact of firm specific factors is exemplified in Brynjolfsson and Hitt (2000) and other research exploring the productivity and complementary effects of information technologies (Evangelista & Mastrostefano 2006).

2.4.3.2 Innovation is uncertain.

Innovation outcomes are difficult to predict. In effect it is possible for innovators to take different courses of action to solve a problem even if they have the same resources, capabilities and access to information (Nelson & Winter 1977).

Uncertainty receives significant coverage throughout the innovation literature. It is generally treated as independent variable producing a specific effect on innovation processes (Jalonen & Lehtonen 2011). Alternatively Foster (2010) argues that uncertainty is a necessary condition for innovation and part of the process of competitive selection that eliminates the errors and mistakes that emerge through innovation processes. Jalonen and Lehtonen (2011) provides a systematic review of uncertainty within the innovation literature and derive eight factors of uncertainty which are summarised in Table 2-8.

Table 2-8. Factors of uncertainty in innovation processes, source: Jalonen and Lehtonen (2011).

Uncertainty Factor	**Manifestation of uncertainty**
Technological	• Due to the novelty of technology its details are unknown. • Uncertainty regarding knowledge required to use new technology.
Market	• Unclear customer needs. • Lack of knowledge about the behaviour of competitors. • Difficulties in predicting the price development of raw materials and competing products and services.
Regulatory/institutional	• Ambiguous regulatory and institutional environment.
Social/political	• Diversity of interests among stakeholders of innovation processes. • Power struggle.
Acceptance/legitimacy	• Necessary skills and knowledge contradict existing skills and knowledge possessed by perceived users of innovation. • Innovation threatens individual's basic values and/or organization's norms.
Managerial	• Fear of failure. • Lack of requisite tools to manage risk inherent in innovation process.

Timing	• Lack of information in the early phases of innovation. • Ambiguity of information in the late phases of innovation. • Temporal complexity.
Consequence	• Indirect consequences. • Undesirable consequences. • Unintended consequences.

Rosenberg (1995) agues that uncertainty also has a number of peculiar properties that shape innovation processes and describes six important dimensions of uncertainty in the context of innovation. These dimensions are summarised in Table 2-9 below.

Table 2-9. Important dimensions of innovation uncertainty, source Rosenberg (1995)

Dimension	**Description**
Hidden usefulness	New technologies often arrive in a primitive state and their usefulness is not always immediately appreciated.
Complementary inventions	The impact of innovation is often dependent on complementary inventions. Additionally some inventions give rise to the search for complementary inventions.
Long gestations	Major new technologies can take many years to replace an established technology. Restructuring and structural deepening in terms of component manufacture can also facilitate a delay.
Unknown systems	Major innovations involving new technologies and systems can be difficult to conceptualise and likely to be handicapped by understandings of those they replace.
Unexpected applications	Predicting the uses of a new technology is difficult and they often have applications in totally unexpected contexts. Some innovations, once established induce further innovations.
Unmet needs	Innovations need to pass an economic test, as well as a technological one. The impact of a new technology is not just a matter of technical feasibility or improved performance; it has to met customer/user needs.

2.4.3.3 Innovation occurs within innovation systems.

Systems based perspectives are commonly employed throughout the innovation literature to assist in understanding important factors that influence the development, diffusion and use of innovations (Ediquist 2005; Hekkert et al. 2007; Smith 2000). The systems based perspective of innovation proposes innovation is a complex system of interaction between the people, processes and technology. It also suggests that innovators operate within institutional systems or networks, collaborating with customers, competitors and suppliers often using common infrastructures and learning systems (Ediquist 2005; Tushman 1977).

Hekkert et al. (2007, p. 413) suggest that one of the central ideas behind the systems based perspective of innovation is that 'innovation and diffusion of technology is both an individual and a collective act'. Ediquist (2005) also argued that innovation behaviour is 'shaped by institutions' that constitute 'incentives and obstacles for innovation'. The main constituents of an innovation system are: (1) organisations – formal structures or actors involved in innovation (individuals and organisations); and (2) institutions – standard routines, methods or rules that regulate interactions and behaviour between and within organisations (Ediquist 2005).

Within the innovation literature there are a number of different approaches used to research innovation systems. Collectively the literature is known as the systems of innovation (SI) approach. Edquist (2001) suggest the various approaches are differentiated by the boundary conditions constraining the scope of investigation. Edquist (2001) describes three overarching approaches to SI research – spatial/geographical, sectorial and functional.

The spatial/geographical approach is generally delimited by boundaries either at the national or regional level. Edquist (2001, p. 14) provides a general definition for national systems of innovation (NSI) approach as comprises 'all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovation'

Edquist (2001) summary of NSI provides important contribution to understandings of SI theory at a general level. First, it provides a list of ten activities than can be expected to be important in most SIs, these activities are summarised in Table 2-10. Second, it emphasises the importance of learning in SIs and describes three types of learning: (1) innovation, as organisational learning and the generation of knowledge based assets and capabilities; (2) research and development; and (3) competence building, training and education, embedded in human resources (individual learning). Finally Edquist (2001) also emphasises the importance of interactions in SIs, describing three types of interaction in an SI: competition – rivalry that creates or influences the incentives for innovation; transactions – the trade of goods and services, which can be knowledge laden; and networking – the transfer of knowledge through collaboration, co-operation and partnerships.

Table 2-10. Important activities for SI, source: Edquist (2001)

Activity	**Description**
Research and development	Creating new knowledge.
Competence building	Provision of education and training for the labour force to be used for innovation and research and development.
New product markets	Formation of new product markets.
Quality requirements gathering	Articulation of quality requirements emanating from the demand side (customers/users) with respect to new products.
Structural and organisational change	Creating and changing organisations required for new innovations.
Networking	Creating and maintaining interactive learning between organisations and markets.
Institutional change	Changing laws, regulations and routines to facilitate innovation.
Incubating activities	Providing access to facilities and administrative support for new innovation efforts.
Financing innovation	Financing the innovation processes.
Innovation consultancy	Provide consultancy services in relation to innovation processes.

The sectorial approach to systems of innovation assumes that innovation is different from sector to sector. Malerba (2002, p. 247) describes a sectorial system of innovation (SSI)[2] as 'a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products'. The SSI approach emphasises the role of knowledge and learning processes, and assumes the system changes (is dynamic) through the co-evolution and transformation of various components (Breschi & Malerba 1997).

Malerba (2002) summarises the components or elements of a SSI as follows: (1) products; (2) agents – organisations and individuals; (3) knowledge and learning processes; (4) basic technologies, inputs, demand, and the related links and complementarities; (5) mechanisms of interactions both within firms and outside firms; (6) processes of competition and selection; and (7) institutions – rules, regulations, etc. Malerba (2002, p. 247) emphasises that 'interdependencies and complementarities define the real boundaries of a sectoral system',

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[2] The literature refers initially to sectorial innovation systems (SIS), but later changes the terminology to be systems of innovation (SI). The abbreviation used in purely for consistency and legibility in this research.

that the boundaries between sectors and related complementary industries are dynamic, and that it is this dynamic that creates the opportunity for growth and innovation.

Similar to interactions described for NSI (Ediquist 2005), Malerba (2002, p. 247) suggests that interaction are shaped by institutions and that they ‘occur through processes of communication, exchange, co-operation, competition and command’.

The third form of innovation system takes a functional approach. The term functional is used to describe the system boundary being focused the activities or function of the innovation system. Carlsson and Jacobsson (1997) argue that the functional interactions of an innovation system are linked the performance of technological innovation systems. This concept has implications for the NSI and SSI approaches and hence a third approach to SI where the boundary is neither geographical or industry based.

Hekkert et al. (2007) outlines the importance of the institutional and evolutionary approaches taken within NSI and SSI approaches, but highlights two shortcomings that can be addressed by the technological innovation systems approach (Carlsson & Jacobsson 1997). First, Hekkert et al. (2007) argue that NSI in particular, do not emphasise enough the dynamic nature of innovation systems. Hekkert et al. (2007) further argue that NSI and SSI are institutionally determined at a macro level where the innovation literature highlights the importance of the entrepreneur and micro-level innovation activity (Rosenberg 1994).

Hekkert et al. (2007) propose a framework that focuses on seven functions that are important for technological innovation systems. These functions can then be used to mapping the key activities associated with a technological innovation system. The functions are summarised in Table 2-11. A detailed method for conducting an analysis technological innovation systems in Hekkert et al. (2011), which is discussed in more detail in section 2.4.4.

Table 2-11. Proposed set of functions for mapping technological innovation systems (Hekkert et al. 2007).

Function	**Description**
Entrepreneurial activities	‘Entrepreneurs are essential for a well functioning innovation system’. They can be new entrants or incumbent companies who diversify their business strategy.

Function	Description
Knowledge development	'Mechanisms of learning are at the heart of any innovation process'. 'This function encompasses learning by searching and learning by doing'. Suggest indicators to map over time are: R&D projects, patents, and investments in R&D.
Knowledge diffusion through networks	'The essential function of networks is the exchange of information'. 'Learning by interacting' Suggest indicators to map over time are: 'the number of workshops and conferences devoted to a specific technology topic, and the network size and intensity'.
Guidance of the search	Refers to 'activities within the innovation system that can positively affect the visibility and clarity of specific wants among technology users'. Suggests that this is 'not solely a matter of market or government influence; it is often an interactive and cumulative process of exchanging ideas between technology producers, technology users, and many other actors'.
Market formation	'New technology often has difficulty to compete with embedded technologies'. Suggest indicators to map over time are: 'the number of niche markets that have been introduced, specific tax regimes for new technologies' and new standards.
Resources mobilization	'Resources, both financial and human capital, are necessary as a basic input to all activities within the innovation system'. Suggests this function is 'difficult to map by means of specific indicators over time', and suggests qualitative data collection methods with participants in the technological innovation system.
Creation of legitimacy/counteract resistance to change	'In order to develop well, a new technology has to become part of an incumbent regime, or it even has to overthrow it. Parties with vested interests will often oppose to this'. Suggest indicators to map over time are: 'the rise and growth of interest groups and their lobby actions'.

Hekkert et al. (2007) maintain that the seven functions also influence and interact with each other, and that there is the potential for many different possible interactions. Hekkert et al. (2007) also maintain that some developments may start with only a limited number of functions interacting in a chain like functional map.

Edquist (2001) positions the NSI approach as generally all encompassing framework for SI. Acknowledging a few limitations (Edquist 2001, p. 15) argue that various lower level geographical approaches, along with the sectorial and functional approaches can be combined in varying permutations as part of a NSI. Specifically (Edquist 2001, p. 15) concludes 'All SIs must be functionally delimited, they must be geographically delimited if they are not global, and sometimes the boundaries of the SIs are also sectorlly (sic) delimited'.

Edquist (2001) argument for a hierarchal organisation of SIs is however contested. Hekkert et al. (2007, p. 413) argue that technologies are seldom 'embedded in just the institutional infrastructure of a single nation or region, since especially in modern society the relevant knowledge base for most technologies originates from various geographical areas all over the world'. At the core of this argument is the notion of globalisation. Smith (2000) suggests that whilst globalisation may be an important factor for innovation systems, national economic policy remains highly influential in setting economic agendas and behaviours. However following on from Hekkert et al. (2007) initial critique of SIs, that they are missing the dynamic elements of innovation and that they are institutionally determined, Hekkert et al. (2007) suggest that under an NSI approach, the dynamics of technological innovation are difficult to map, because of the complexity and large numbers of actors, network relations, and institutions.

Both the geographical, sector and functional based approaches have been shown to provide important insights into innovation behaviours. Each have their strengths and weaknesses and they are not so much theoretically incompatible that their use could not be integrated under the single framework of SI.

2.4.3.4 Innovation and path dependency

Innovations are the product of their histories. Within the economics and innovation literature it is widely accepted that technology progresses along an evolutionary path or trajectory of designs of related products and services (Dosi 1982). Arthur (1989) and David (1986) advance the notion that development can sometimes become locked-in within a trajectory where organisations and individuals are unable to adopt new innovations from the outside (Runge 2014). The theory associated with this lock-in is referred to as path dependency.

The classical model of path dependency (Arthur 1989; David 1986) proposes for a given technological innovation, advancement progresses in a series of steps. Initially there are a variety of options and decisions that can be made concerning a path for advancement, but with each step or advancement the probability of continuing along the same path increases because 'the relevant benefits of the current activity compared with other possible options increase over time' (Pierson 2000, p. 251). This self-reinforcing feedback mechanism is referred to as increasing returns. Eventually the cost to exit or switch to alternatives rises to a point where the path becomes locked-in. It is argued that the path dependence phenomena can occur within and across organisations (Sydow, Schreyögg & Koch 2009)

Both Arthur (1989) and David (1986) provide similar interpretations of the factors or processes that lead to increasing returns (Martin & Simmie 2008). A comparison is provided in Table 2-12 below.

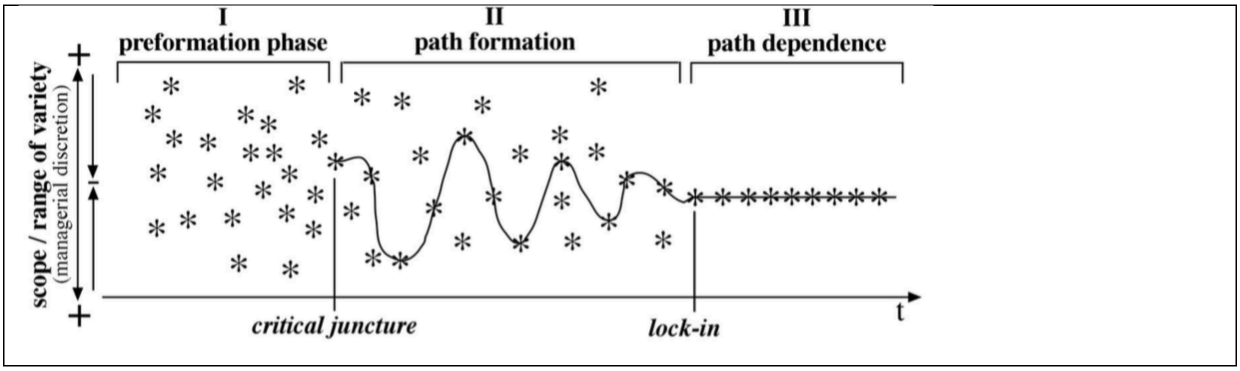
Table 2-12. A comparison of the mechanisms for increasing returns (Martin & Simmie 2008).

Arthur (1994)	**David (1986)**
Large fixed, initial set-up costs. *Dynamic learning effects* – learning by doing, learning by interacting and learning by using all tend to entail positive feedbacks. *Co-ordination effects* – which confer advantages to ‘going along’ with other economic agents taking similar actions. *Self-reinforcing expectations* – where the increased prevalence of a product, process or practice enhances beliefs of further prevalence.	*Technical interrelatedness* – the reinforcing effects of complementarity and compatibility between different components of a technology and its use). *Economies of scale* – the benefits associated with the use of a technology as it gains in acceptance relative to other systems. *The quasi-irreversibility of investments* – in effect the inertia of sunk costs arising from the difficulties of switching technology-specific capital and human skills to alternative uses.

Sydow, Schreyögg and Koch (2005) extend the classical model of path dependency arguing that (1) path creation decisions are not random but purposeful; and (2) the model is incomplete and that it should address how paths break up and dissolve (Martin & Sunley 2006). Sydow, Schreyögg and Koch (2005) describe the classical model as a dynamic theory with three different stages (illustrated in Figure 2-18):

- Stage I the preformation stage – where choices are unconstrained and decision makers conduct undirected search process;
- Stage II the path formation stage – options are start to narrow and agents do not seem to have a choice anymore (increasing returns); and
- Stage III the path dependence stage – lock-in.

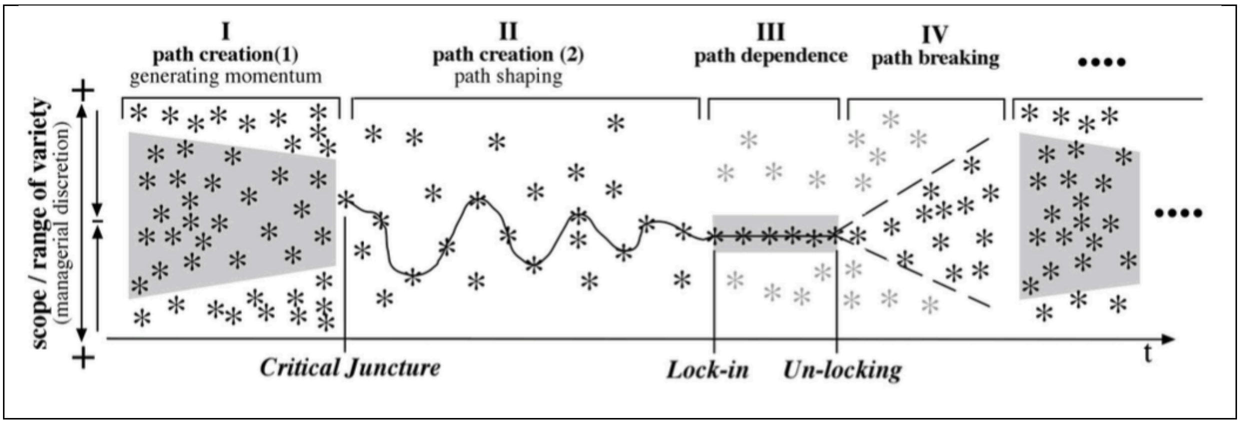
Figure 2-18. Classical model phases (Sydow, Schreyögg & Koch 2005)



The extended model is illustrated in figure 2-17 and incorporates two additional phases:

- Splitting the preformation phase in to two-path creation phases where initial undirected search and random selection are present but 'deliberate initial decisions, investments or intended resource allocations' are also present. Paths are then shaped, where earlier decisions shape later ones.
- Adding in a path-breaking phase to incorporate an unlocking mechanism.

Figure 2-19. Extended model phases (Sydow, Schreyögg & Koch 2005)



Fagerberg, Verspagen and Mowery (2008) suggest that theory associated with path dependency has been influential in the innovation literature. Many innovations are incremental improvements upon existing products and processes etc. As a consequence innovations are historically constrained and a product of history. This creates opportunities for improvement, modularisation or disruption and change (Arrow 2000; David 1986).

Whist path dependency and lock-in can see innovators select inefficient and inflexible paths (Arthur 1989), the impacts associated with complementary resource and network externalities suggest that path dependency in part of a desirable dynamic cycle of innovation (Liebowitz & Margolis 1995).

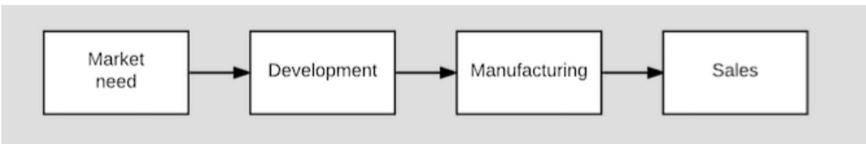
2.4.3.5 Innovation processes

Innovation processes are the interrelated activities and interactions between actors that progress innovation. Across the literature innovation processes are often conceptualised as models depicted as phases, stages or a network of links between processes and actors. To initiate a discussion on innovation process models it is useful to revisit the generalised model of technological change initially discussed in section 2.4.2.1, where technology development is conceptualised as following a sequence of invention, innovation and diffusion. Whilst it is argued that a model is unrepresentative of innovation processes, it must be acknowledged that it was the starting point for an evolving view of innovation process models. Understandings from this earlier synthesis of innovation processes are still relevant to current understandings (Rothwell 1994).

The focus and understanding of innovation processes have evolved over time (Rothwell 1994). Tidd (2006) argues that this evolution has seen the focus shift from distinctly linear models of innovation toward more interactive and dynamic models of innovation. Rothwell (1994) provides a definitive summary of the evolution of innovation process models over time. Rothwell (1994) describes the different theories as generational models.

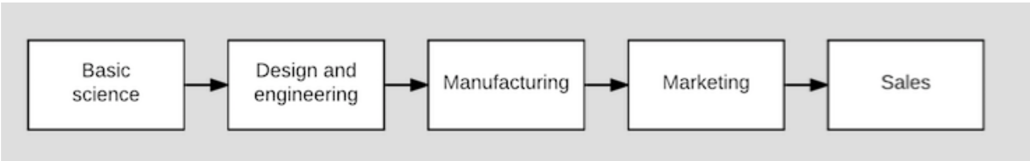
Rothwell (1994) first and second generations are distinctly linear. The first is cited as the classical innovation model and often distinguished as the technological push model where innovation progress through a sequence of five phases – basic science, design and engineering, manufacturing, marketing, and sales.

Figure 2-20. First generation model technology push (Rothwell 1994).



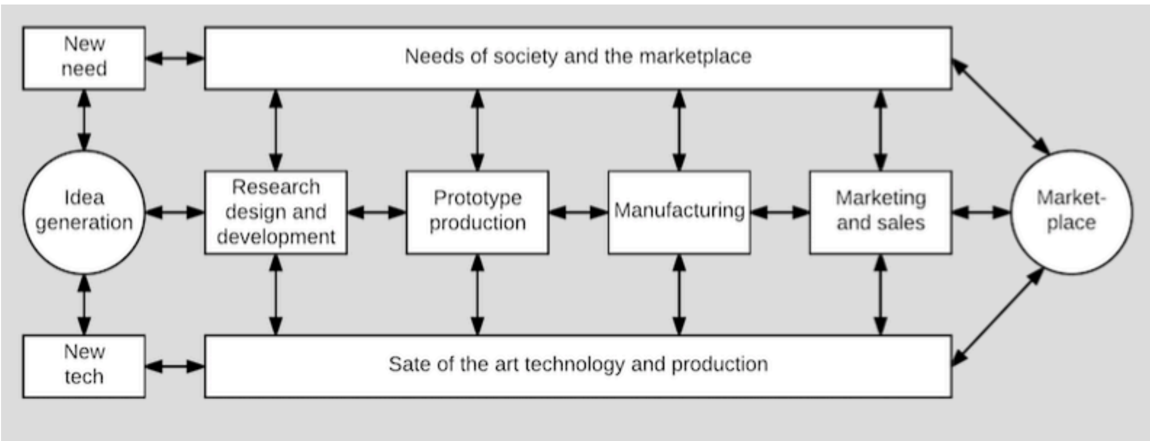
The second generation recognised the growing importance of the incremental development of existing technologies and the role of markets in shaping demand. The market pull model introduced a revised sequential model where innovation progressed through four phases – market need, development, manufacturing and sales.

Figure 2-21. Second generation model market pull (Rothwell 1994).



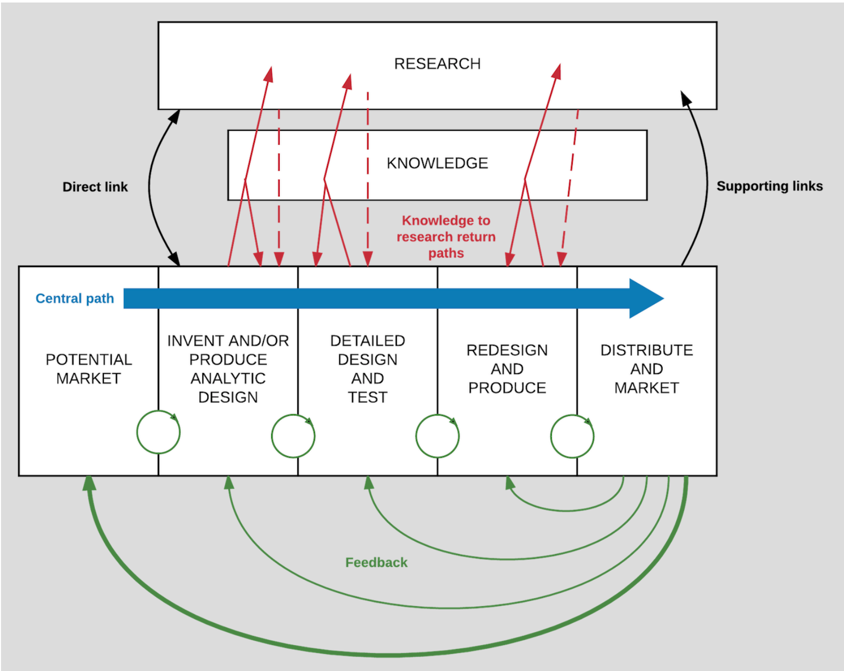
The third generation model initiates a departure from completely linear conceptualisations of the innovation process. Rothwell (1994) maintains that understanding within the third generation process were still essentially sequentially focused, but the notion of feedback between and within the phases emerged from innovation studies. Rothwell (1994) third generation models are essentially phased and interactive.

Figure 2-22. Third generation phased and interactive model (Rothwell 1994).



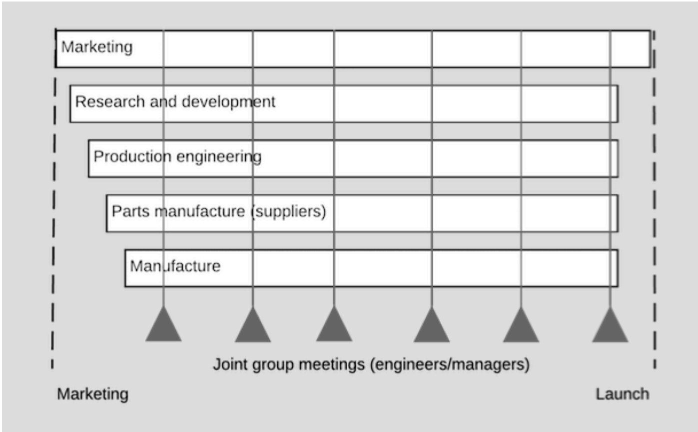
At a similar time Kline & Rosenberg (1986, p. 275) were also highly critical of the linear models of innovation and argue that innovation 'was neither smooth nor linear, nor often well behaved'. Kline & Rosenberg (1986) downplay the importance of technology push and market pull and provide an alternative model of the innovation processes that emphasises important relationships between research, invention, innovation and production. This model is often described as a chain-linked model and it comprises a central chain-of-innovation or path encompassing design, development, production and marketing. The model also introduces a series of iterative feedback links between the components along the central path, and alternative paths that represent the flow of information and collaboration with the science and research domain. Figure 2-23 below illustrates this model which has similarities with Rothwell (1994). However Kline & Rosenberg (1986) acknowledge the broader role that science and research play in the extended support of technological innovation.

Figure 2-23. Chain linked innovation process model (Kline & Rosenberg 1986).



The Rothwell (1994) fourth generation sees the innovation models moving away from the sequential phases and introduces the need to collaborate beyond the boundaries of the firm. Fourth generation understandings see innovation processes as parallel and activities as the focus shifted towards perceived advantages associated with the speed of innovation and an emphasis of vertical and horizontal integration with suppliers and distributors. Rothwell (1994) indirectly cite the work of Takeuchi and Nonaka (1986) which is a forerunner to the agile methods used in conjunction with software development (see section 2.3.3).

Figure 2-24. Fourth generation model parallel and integrated (Rothwell 1994).



Rothwell (1994) anticipates a fifth generation of innovation processes models largely building on existing understandings but emphasising the role of networks in innovation processes. Fifth generation process models are therefore significantly linked to innovation systems.

Rothwell (1994) generational typology is more a depiction of the temporal evolution of understandings associated with innovation processes. Elements form each area have been largely incorporated (and discarded where appropriate) into the current theory. Specific industries and type of innovation may still conceivably run highly planned and sequential innovation processes.

There have since been several new process based concepts emerge in the innovation literature since Rothwell (1994). Tidd (2006) highlights the market linked models described by Christensen and Raynor (2003) that are associated with disruptive innovation, and the role of knowledge in the innovation process is stressed throughout the literature linked to innovation systems.

Disruptive innovation deals with gaps in product performance and cost, and non-consumption within existing markets. The term disruptive innovation is often associated with classifying a specific type of innovation (see section 2.4.2.2), however the concept specifically refers to an innovation processes whereby an innovation is used to compete with established technologies or business models on the basis of targeting product performance features that exceed or ignores the needs of some market segments (Christensen, Raynor & McDonald 2015).

Disruptive innovation processes effectively setup development paths or trajectories that typically move from the lower end of product performance into the mainstream, catching incumbent business who are focused on sustaining innovation along a trajectory of higher product performance and profitability off guard. Notions of disruptive and sustaining innovation processes emphasise that technology push and market pull still represent an important element of the innovation process. Tidd (2006) argues that interaction between the two is the critical element.

A great portion of the contemporary innovation literature places knowledge at the heart of many innovation processes. (Evangelista & Mastrostefano 2006, p. 247) emphasise that domain knowledge is in essential part of the innovation process and describe the innovation process as being 'conceptualised as a composite set of searching and problem solving activities requiring different types of knowledge assets, technological inputs, competencies and skills (Dosi 1988)'.

Through innovation processes, new and existing knowledge is routinely incorporated into products, processes and services (Popadiuk & Choo 2006). Knowledge is often combined with technology to create innovations either as new knowledge and technology, new uses or combinations of existing knowledge and technology. Technologies in themselves are essentially the embodied knowledge of a productive process (Baetjer 1997).

Gaining access to non-tradable assets such as knowledge is also an important part of the innovation process (OECD/Eurostat 2005). The emergence of research relating to innovation systems (see section 2.4.3.3) was in part associated with satisfying the need to map knowledge flows and networks associated with innovation.

Within the innovation literature there is also a number of studies that explore user-centred innovation. User centred innovation seeks to distinguish between innovation undertaken by the manufacturers of goods and services and that which is undertaken by the users of goods and services. The concept arose out of insight provided by Von Hippel (1986), which introduced the theory that a specific class of users defined as lead users had the potential to identify commercially attractive innovation opportunities. (Von Hippel 1986, p. 791) defines a lead user as 'users whose present strong needs will become general in a marketplace months or years in the future.' Further study of the claim was undertaken and several empirical studies revealed users engaged in developing or modifying products account for 10 to 40 precent of users (Von Hippel 2005); that there is a significant correlation between lead users and innovation; and many innovations developed by lead users are often commercialised by manufacturers.

Von Hippel (2005) suggests that there are two primary reasons as to why users tend to innovate rather than simply adopt. The first reason is that some users like to innovate, they 'value the process of innovating because of the enjoyment or learning it brings them' (Von Hippel 2005, p. 7). The second reason involves agency costs. Agency refers to a contract relationship where by one party (the agent) provides services for another party (the principal) that also involves delegating some decision-making authority to the agent. Agency theory is concerned with the risk that the agent may not always act in the interests of the principle. Agency costs are the costs associated with those risks – the cost of monitoring the agent (monitoring expenditure), the cost of ensuring the gent acts in the principal's best interest (bonding) and the cost of any residual loss i.e. the outcome not meeting the principal's requirements (Jensen & Meckling 1976; Von Hippel 2005).

2.4.3.6 Innovation and complexity

A final but important characteristic of innovation highlighted throughout the literature is that innovation is complex. It is important to distinguish between complex and complicated phenomena (Martin & Sunley 2007). Complicated phenomena are usually made of many constituent parts. It is possible to understand and model complicated phenomena by reduction or decomposition of these parts i.e. by examining their function or purpose. Complex phenomena on the other hand cannot be understood by simple reduction or decomposition. Complex phenomena comprise non-linear interactions that give rise to 'outcomes that are not sufficiently understood as a sum of their parts' (Goldstein 1999, p. 53).

Theory associated with the study of phenomena under conditions of complexity is extremely diverse and crosses into many domains of scientific and social research. Lane (2011) delineates between various theoretical approaches: (1) those concerned with inferential modelling techniques; (2) as a class of mathematical computation systems; and (3) as a term that applies to physical, biological and social phenomena concerned with concepts such as emergence, self-organisation, robustness and networks. Within the domain of innovation research, complexity theory is predominately of the third variety and often described as the study of complex systems. Not withstanding there are important branches of economics research that overlap with innovation theory using various mathematical modelling theories (e.g. Chaos theory).

Pavard and Dugdale (2006, p. 40) define a complex system as ‘a system for which it is difficult, if not impossible to reduce the number of parameters or characterising variables without losing its essential global functional properties’. Martin and Sunley (2007) provide a summary of the key properties and attributes of complex systems from the extant literature (see extract in Table 2-13).

Table 2-13. Key properties of complex systems, extract from Martin and Sunley (2007).

Property	**Attributes**
Distributed nature and representation	The functions and relationships are distributed across system components at a whole variety of scales, giving the system a high degree of distributed connectivity.
Openness	The boundary between a complex system and its environment is neither fixed nor easy to identify, making operational closure dependent on context (and observer). Such non-isolated systems tend to be dissipative—subject to constant interaction and exchange with their environments.
Non-linear dynamics	Complex systems display non-linear dynamics because of various complex feedbacks and mutually self-reinforcing interactions amongst components. Complex systems are thus often characterized by path dependence.
Limited functional decomposability	Because of its high degree of connectivity, and the open, dynamic nature of its structure, there is limited scope for decomposing a complex system into stable components.
Emergence and self-organization	There is a tendency for macro-scale structures and dynamics to emerge spontaneously out of the micro-scale behaviours and interactions of system components[3].
Adaptive behaviour and adaptation	The same processes of self-organization imbue complex systems with the potential to adapt their structures and dynamics, whether in response to changes in the external environment, or from within through co-evolutionary mechanisms or in response to ‘self-organized criticality’.

[3] Also see Feibleman (1954) theory of integrative levels.

Property	Attributes
Non-determinism and non-tractability	Complex systems are fundamentally non-deterministic. It is not possible to anticipate precisely their behaviour even if we completely know the function of their components. This does not imply, however, that the behaviour of such systems is random, in the sense of being haphazard.

The characteristics and dimensions we have previously discussed throughout this section i.e. pervasiveness, uncertainty, innovation systems, path dependency, and interactive processes contribute to the view of innovation being viewed as complex phenomena.

Complexity theory and the role of complex systems in innovation phenomena are well covered in the innovation literature. Damanpour (1996) for example highlight that innovation depends on a range of complex factors that limit the predictive application of various theories and models. Miller et al. (1995), Etzkowitz and Leydesdorff (2000), and Ethiraj and Levinthal (2004) are examples of complex systems theory applications within innovation systems research.

There are often a range of unique characteristics and dimensions associated with complex systems and innovation within a specific industry, sector or area of application. Rosenberg (1994) suggests that to understand innovation beyond more general concepts inevitably involves drilling down into the domain to examine the common patterns and cases.

2.4.4 Conducting innovation research

Contemporary innovation research came about with a resurgence of interest in the study of innovation following World War II. Fagerberg and Verspagen (2009) trace the resurgence back to 1945 with the establishment of the Research and Development (RAND) Corporation. Research conducted by the RAND Corporation was focused on technology research and development with a view to determine the factors that affected the success or failure of research and development activities. This research brought new understandings about the role of uncertainty and how the organisational and institutional factors that facilitated innovation varied across different sectors. The resurgence of innovation research gave rise to endogenous-growth theory (Arrow 1962), evolutionary theories of economic growth (Nelson & Winter 1974) and improved understandings of diffusion and spread of innovations (Rogers 1962).

Until the establishment of the Science Policy Research Unit (SPRU) at Sussex University in 1965 (Fagerberg 2005) innovation had been studied from a resource allocation (input) and an economic effect (output) perspective. The process of innovation had been largely ignored and treated like a 'black box' (Rosenberg 1976). Researchers at SPRU would soon argue that innovation was more than just research and development (R&D) or scientific in nature and that innovation encompassed a much broader range of activities that had not been initially explored by researchers.

By the 1990s a significant body of theory and empirical work had progressed around innovation. The OECD initiated enquiry into survey data collection and measurement practice for the study of innovation (Smith 2005). This initiative lead to a consensus in relation to the survey measurement techniques and practices associated with innovation research. In 1992 the OECD published a consolidated guide for collecting and interpreting innovation data that became known as the 'Oslo Manual'.

The Oslo Manual has since become a reference for a number of large scale surveys examining the nature and impacts of innovation in the business sector (OECD/Eurostat 2005). One of the more significant of these has been the Community Innovation Survey (CIS). The CIS was initiated with a view to obtain internationally comparable measures for innovation output and has since become the main data source for measuring innovation in Europe. The CIS and other similar surveys combined to provide new theories relating to innovation that have led to refinements within the Oslo Manual.

The Oslo Manual currently provides a comprehensive consolidation of contemporary innovation theory. It is primarily concerned with innovation at the level of the firm and specifically, knowledge of innovation activities and factors that affect the firm's ability to innovate. Within its scope are product, process, organisational and marketing innovation. It also includes innovation associated with diffusion, but 'excludes changes that are minor or lack sufficient degree of novelty' (OECD/Eurostat 2005). The Oslo Manual also defines a number of key areas for data collection: (1) innovation activities and expenditures, (2) factors influencing innovation, (3) the impact of innovation and (4) linkages in the innovation process. For each area there are descriptions drawn from the innovation literature outlining important characteristics and dimensions to be considered by researchers. They are generally not domain or industry specific, rather they are oriented to the general phenomena of innovation.

The Oslo Manual provides guidance with respect to the collection and use of data for innovation research, but by virtue of its coverage it also provides an excellent framework for understanding key elements of current innovation theory.

The main theoretical areas the Oslo Manual covers are:

(i) Classifying innovations – describing the generic types of innovation, what is and is not considered innovation, institutional classifications and the concept of an innovation active firm;
(ii) Linkages in the innovation process – inbound and outbound diffusion, stressing the importance of understanding how transfers of knowledge take place, the main sources of knowledge and technology flows;
(iii) Defining innovation activities – discussing six areas including: in-house R&D, external R&D, acquisition of external knowledge, the acquisition of machinery, equipment and other capital goods, other preparations for innovation e.g. design, planning and testing of production processes and delivery methods, and training; and
(iv) The impacts, incentives and obstacles to innovation – suggesting a range of factors influencing objectives and target outcomes, the impacts on output, productivity and employment, barriers and reasons for not starting innovations such as cost, knowledge, market and institutional environments and methods for appropriating the gains of innovation.

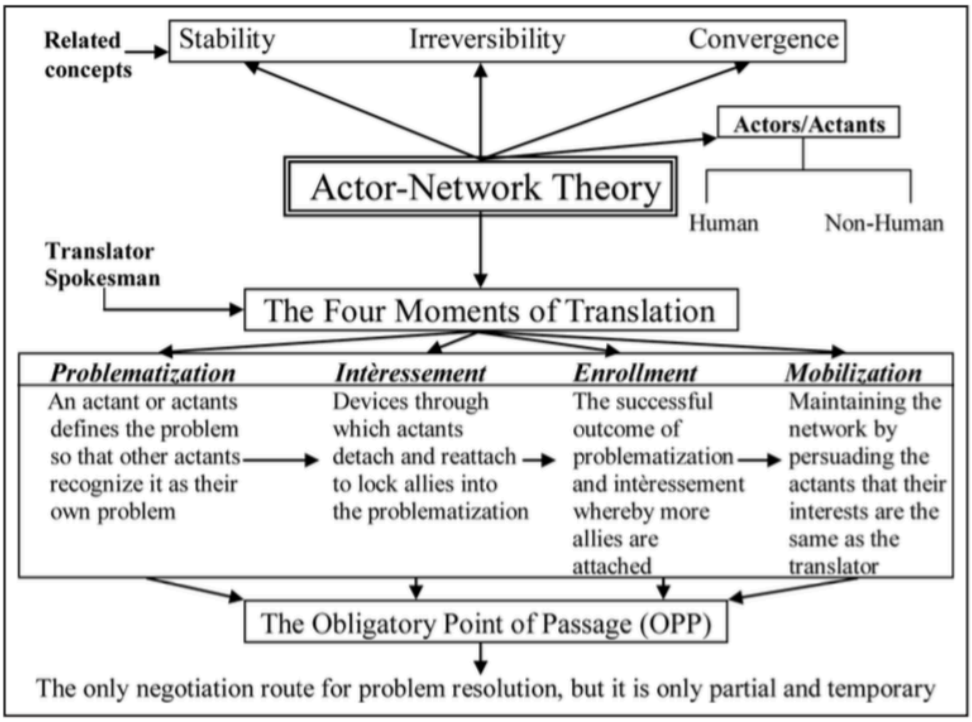
2.4.4.1 Alternative socio-technical approaches

Whilst the Oslo Manual (OECD/Eurostat 2005) covers a broad range of contemporary innovation research, inter-disciplinary studies within the domain of science, technology and society (STS) arguably provide a number of theoretical and methodological contributions relevant to the study of socio-technical systems.

The most significant of these methods in the context of innovation is Actor-Network Theory (Callon & Law 1986; Latour 1987). Actor-Network Theory (ANT) is predominately an analytical framework that can be used to research socio-technical change. ANT maintains that social structures are "patterned networks of heterogeneous materials" (Law 1992) and it is primarily concerned with the formation, dynamics and translation of these networks in the context of actors and their aligned interests. A key theoretical assumption associated with ANT is the notion of human and non-human elements as equal actors in socio-technical systems i.e. ANT would provide agency to technological artefacts in the study of social-technical system.

Although there are many variations in research methods, studies that utilise ANT as an analytical strategy generally attempt to map or translate actors and their behaviours to the relevant networks. Rhodes (2009) provides an excellent diagrammatic overview ANT and the translation process (see Figure 2-25 below).

Figure 2-25. ANT overview *(Rhodes 2009)*



ANT has been used in a range of innovation related studies. Examples include Callon (2004) that discusses the participation of non-human actors in innovation design processes, Harrisson and Laberge (2002) that examines the innovation diffusion process in a large microelectronics firm, and Geels and Schot (2007) that looks at transition pathways associated with innovation in sociotechnical systems. Tatnall and Gilding (2005) also propose a case for an innovation to be viewed as an actor-network, particularly in the context of information systems implementation.

Whilst ANT provides an alternative pathway for examining IT innovation, there are several important theoretical positions that potentially limit its use in various research contexts. For example the equal or "symmetric treatment for humans and nonhumans in actor-network theory has been the cause of considerable controversy" (Walsham 1997), particularly in the context of a subjective or relativist ontology.

The limitations and issues associated with the discourse on technological determinism, the social construction of technology (SCOT) and the social shaping of technology (SST) are discussed further in Chapter 3.

2.5 Theoretical framework and research issues: developing a heuristic approach

The previous sections of this chapter introduce and discuss the literature relevant to IT innovation in the context of information systems and innovation theory. These two parent theories overlay complementary and sometimes divergent perspectives relating to IT innovation.

Information systems theory covers off on the design, development, implementation and use of IT within organisations and society. A great deal of the research draws on technology diffusion and adoption perspectives. It highlights how organisations realise the value from IT development and describes important techniques associated with the methods of design and implementation of technological and organisational change. A key area of information systems theory relating to IT innovation is the literature concerning IS implementation. This research provides important understandings of factors relating to success or failure of IS implementation, the role of user-designer interaction, the processes associated with implementation and adoption, and political factors that facilitate or impede IS implementation (Kwon & Zmud 1987).

Whilst the theoretical and empirical work concerning IS implementation provides an important contribution to understandings of IT innovation, this research is dominated by diffusion and adoption based perspectives of innovation (Fichman 2004; Ruttan 1996).

Fichman (2004) emphasises that IT innovation research needs to move beyond this dominant paradigm to further understand what may be other important dimensions IT innovation.

Diffusion of innovation theory (DOI) used in the context of IS implementation has also been the subject of substantial criticism. DOI assumes that technologies are discrete packages that diffuse into a fixed homogenous environment. This has been found to be particularly untrue in the case of large complex information systems where implementation and adoption can be subjected to a range of alterative social interpretations in relation to context (Lyytinen & Damsgaard 2001). DOI also implies that the adoption process follows a rational process of careful analysis and selection in order to maximise the benefits of the proposed adoption (Lyytinen & Damsgaard 2001). A notion particularly at odds with principles of uncertainty and entrepreneurship found within the innovation literature. There are also problems determining a definition for operational adoption and distinguishing between acquisition at the organisational level, and adoption at the end-user or individual level (Bayer & Melone 1989). Issues also remain with the under emphasis of unsuccessful, abandoned or incomplete innovations (Rogers 1995) and under representing the influence of historical choice and path dependence (Arthur 1989; David 1986).

The theoretical and empirical work concerning IS implementation is also somewhat fragmented and contrasting (Agarwal & Lucas 2005; Lucas, Swanson & Zmud 2008), particularly in the context of defining and understanding IT innovation. Previous research has attempted to examine and unify these contrasting perspectives. It has endeavoured to combine macro-level perspectives of innovation theory with the micro-level understandings of IT innovation practice from the IS implementation literature (Kwon & Zmud 1987; Mustonen-Ollila & Lyytinen 2003). Swanson (1994) integrates perspectives from organisational innovation to map different types of IT innovation to organisational assets and capabilities; Lyytinen and Rose (2003) explore IT innovation in the context of disruptive innovation theory (Christensen 1997), and further call for a dynamic theory of IT innovation; and Wang and Ramiller (2009) emphasise the role of acquiring new, or modifying and reinforcing existing IT knowledge, through community interaction.

The theoretical and empirical work relating to IT/IS development and engineering is also an important source of knowledge relating to IT innovation. The knowledge relating to development and project management methodologies within the IT/IS disciplines provide considerable insight into activities and process involved in the successful development and adoption of IT/IS. Some of this knowledge is bound to notions of prescriptive staged/linear development processes, however recent IS/IT development practices have begun to adapt interactive and emergent techniques more commonly associated with innovation theory.

Whilst this body of work remains highly relevant, it potentially overlooks factors associated with technological product and process innovation. There are also number of prevailing issues associated with (1) the limited differentiation of IT innovation from IT development, implementation and evaluation processes; (2) a lack of insight into the different ways in which IT innovation occurs in practice, and the factors important in any determination of IT innovation success and/or sustainability; and (3) a prevalence of assumptions that IT innovation can be meaningfully conceptualised through a linear model of staged activities.

Theoretical insights from the innovation literature highlight the pervasiveness of innovation processes and the important role of collaboration amongst customers (users), competitors and suppliers operating within innovation systems. Innovation theory also emphasises the complex nature of innovation, the role of uncertainty and the emergent non-linear nature of technological developments that are themselves historically constrained and temporally situated.

The experience and research knowledge obtained from empirical studies outlined in the Oslo Manual (OECD/Eurostat 2005) have also assisted to consolidate and unify the important theoretical dimensions of innovation.

Whilst innovation theory may appear to have the potential for furthering understandings IT innovation, there is however limited empirical work conducted within this domain, nor is there any research that utilises the consolidated guidance for studying innovation presented in the Oslo Manual (OECD/Eurostat 2005).

Where IT innovation may have been explored within the innovation literature, theory and empirical data is often abstracted a general or macro level. Rosenberg (1982) stressed this issue in the context of technological change and argued that technological change was different between sectors. Arguably innovations with different technologies required different innovation systems. The detailed descriptions of innovation in one industry are unlikely to be relevant to another. Rosenberg (1994) advocates that insights into the process by which technological knowledge grows should involve a detailed examination of the sequences of events and institutions within particular industries or sectors.

In summary the IT/IS implementation literature provides important theoretical and empirical knowledge within information systems theory to support the best explanation about what IT innovation is and what it involves. However it does not capture everything. It has been demonstrated in a few studies that understandings of innovation theory can assist to provide clarity and improve understanding of IT innovation. The potential overlapping (and non-overlapping) relationships between information systems theory and innovation theory in the context of understanding IT innovation are illustrated in Figure 2-26. Descriptions of the overlapping areas of knowledge are also provided in Table 2-14.

In this context several issues worthy of further research can be identified at the intersection of the research literature:

- Potentially untested knowledge of IT innovation from within innovation theory or from other theoretical domains remains a possibility ('3+4' overlaps).
- Many shared and common understandings that seem implicit in the information systems and innovation literature have not been empirically tested in the context of IT innovation ('1' overlaps).
- Despite the existence of shared and common theoretical positions, there are still conflicting issues across both domains that require further clarification and understanding. For example there is no clear definition for IT innovation that includes elements of innovation beyond the diffusion and adoption perspective.
- There is no coherent framework or guidance for capturing information about IT innovation that relates directly to the contemporary literature pertaining to innovation.

Figure 2-26. The parent theory overlay for understandings of IT innovation.

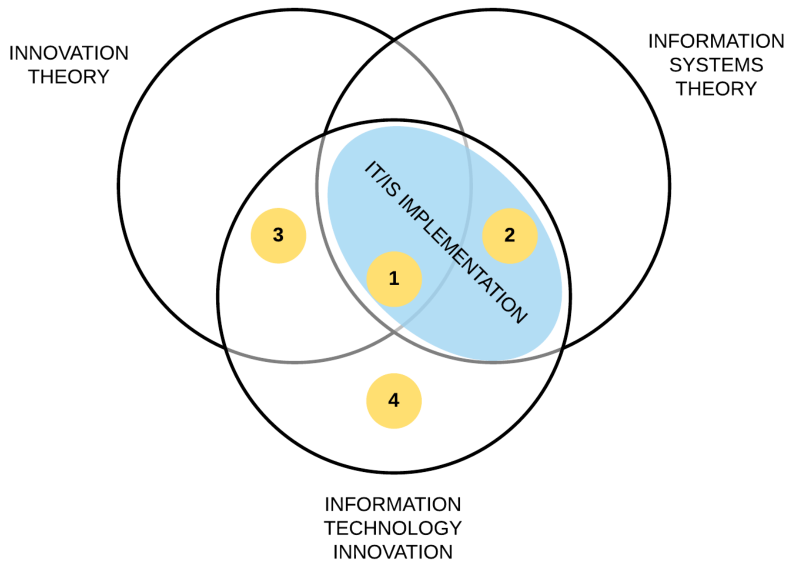


Table 2-14. Descriptions of the overlapping areas of knowledge associated with IT innovation

Area of Knowledge	Description
1	Shared and common understandings of IT innovation from both information systems and innovation theory.
2	Understandings of IT innovation exclusively from information systems theory.
3	Understandings of IT innovation exclusively from innovation theory.
4	Understandings of IT innovation outside of information systems and innovation theory e.g. management science.
1 + 2	Current empirically tested knowledge of IT innovation, encompassing IT/IS implementation theory.
3 + 4	Potentially untested knowledge of IT innovation from innovation theory, or from other theoretical domains.

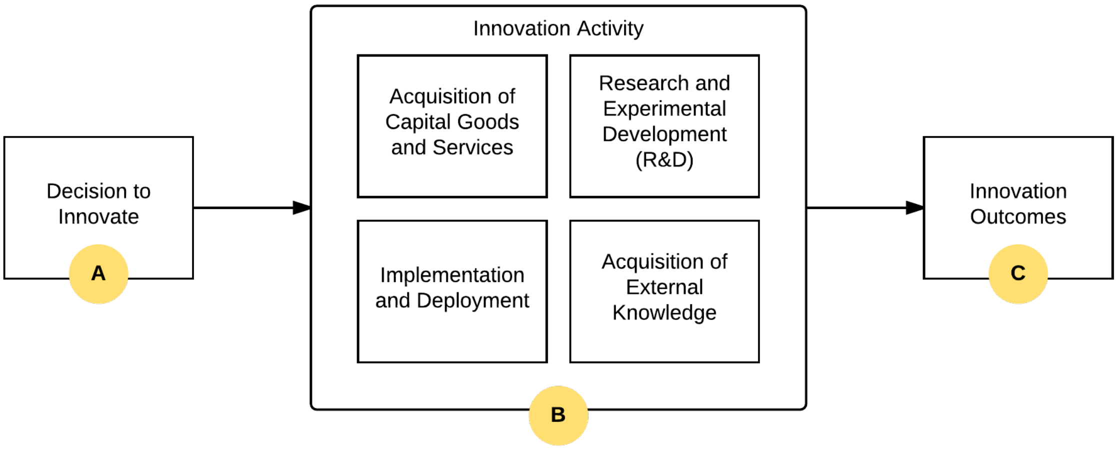
This research proposes that the key issue for understanding IT innovation is that information systems theory should be linked to contemporary innovation theory in order to establish a consolidated view of IT innovation. Linking these theories through the common notions of diffusion and adoption have already been shown to assist understanding IT innovation. Extending this work and incorporating additional dimensions of innovation theory may also assist to consolidate IT innovation research.

Such a proposal is also supported in the IS/IT literature. Lucas, Swanson and Zmud (2008, p. 8) argue that 'that innovation and innovation-induced transformation provide powerful lenses through which to view the IS field', and suggest that recent innovation theory has the capacity to correct earlier deficiencies in implementation research. Lucas, Swanson and Zmud (2008, p. 8) recommend that information systems theory needed to account for the technological, institutional and historical context of IT/IS implementation and that research should be 'oriented toward telling rich and complete stories of innovation with information technology'. This view is also supported within the innovation literature that highlights the diversity and pervasiveness of innovation across all sectors of the economy. Rosenberg (1994) suggests that to understand innovation beyond more general concepts inevitably involves drilling down into the domain to examine the common patterns and cases. Lucas, Swanson and Zmud (2008) also wanted research to focus on how IT innovation become involved in the creation of organisational capabilities and competitive advantage.

To this end the high level guidance provided within the Oslo Manual (OECD/Eurostat 2005) may provide a potential launching pad to guide the exploration of IT innovation. As discussed in the previous section, the Oslo Manual (OECD/Eurostat 2005) provides comprehensive consolidation of contemporary innovation theory. It provides specific guidance for innovation data collection that is founded upon the experience and research knowledge obtained from empirical studies relating innovation. It is important to acknowledge that the data collection guidance provided by the Oslo Manual (OECD/Eurostat 2005) is oriented towards the general phenomena of innovation. The guidance is generally not domain or industry specific, but arguably well suited to providing a high level framework for exploring innovation data.

It is possible to reconstruct and summarise the guidance relating to innovation data found in the Oslo Manual (OECD/Eurostat 2005) using a traditional A-B-C antecedents, behaviour and consequences heuristic model (Brancheau & Brown 1993; Skinner 1938), where the antecedents are represented by IT innovation decisions, behaviour is represented by IT innovation activity and consequences are represented by IT innovation outcomes (see Figure 2-27).

Figure 2-27. Summarised model for innovation data collection adapted from OECD/Eurostat (2005)

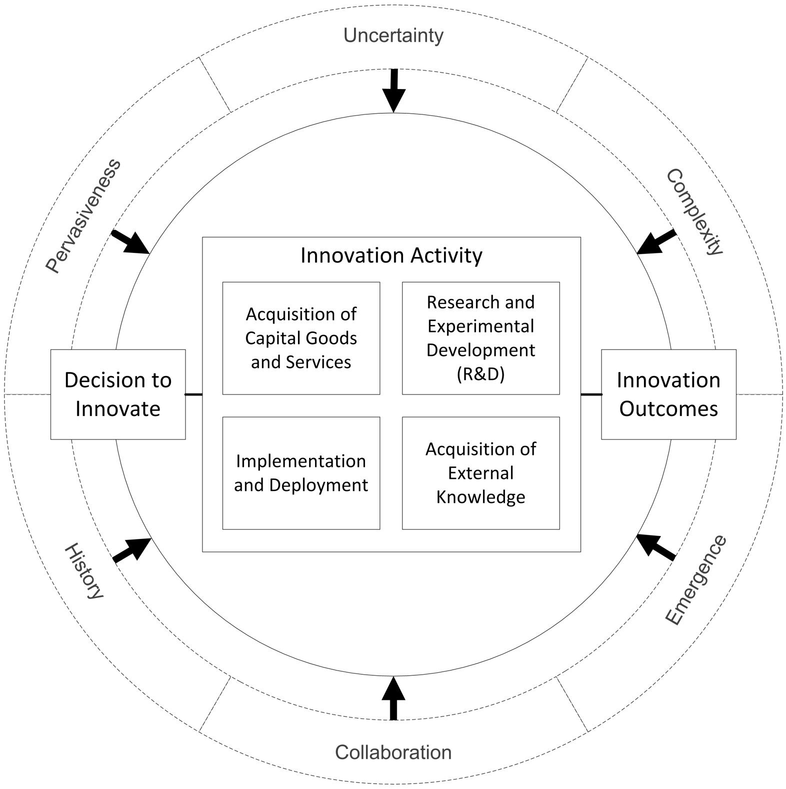


The core elements of this model are:

A. The decision to innovate – understanding the reasons, motivations and/or objectives driving innovations;
B. Innovation activity – 'all scientific, technological, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations' (OECD/Eurostat 2005). This includes activity associated with research and experimental development, the acquisition of capital goods and services, the acquisition of external knowledge and activities associated with implementation and deployment; and
C. Innovation outcomes – understanding the economic and social outcomes associated with innovation. Asking about the success or failure of innovation activities and possibly measuring the impact of innovation in terms of organisation performance, degree of novelty, breadth of diffusion and the creative effort required to progress innovation (OECD/Eurostat 2005; Smith 2005).

The summarised Oslo Manual based model can be further elaborated to accommodate the general theoretical characteristics and dimensions of innovation described in section 2.4.3, adding the pervasiveness and complexity of innovation; the uncertain and emergent nature of innovation; the role of collaboration within institutional structures and ecosystems; and the lasting implications of historical choices and events.

Figure 2-28. An elaborated theoretical framework for innovation data collection



The resulting model is a heuristic device to assist the researcher to explore IT innovation practice, confirming what is real, relevant and potentially missing from our understanding of IT innovation. The same heuristic also has application for guiding analysis, acting as a skeleton or organising framework for discussion of IT innovation in the context of innovation theory.

2.6 A review of the literature after data collection

This research uses the existing literature at the beginning of this study to justify the research and to identify research issues and problems associated with IT innovation. However because the objective of this research is to extend or modify existing theory, it also uses prior theory to support the findings (see Chapter 3, Section 3.3.2.5). The use of prior theory towards the end of a study, during the analysis and interpretation phases is advocated by Eisenhardt (1989b) and described as enfolding the literature. A detailed review of this literature in this context is conducted in Chapter 6, Section 6.4.

The following section provides a brief summary of relevant literature utilised to support themes that emerged after data collection and during analysis, that where not part of the initial literature review.

The first area of theory relates to the notion of radical innovation, which has been shown to be the subject of different interpretations within the literature. Silverberg and Verspagen (2005) argue that all innovation is fundamentally incremental. The general argument against this distinction have some support in the innovation literature and are provided in terms of novelty and diffusion (Silverberg & Verspagen 2005).

The concept of IT innovation lifecycles also emerged from the data analysis. Lifecycle models are prevalent in both the innovation and information systems literature. Rogers (1962) and Bass (1969) for example provide a widely accepted diffusion and adoption lifecycle model. Lifecycle concepts, including the use logarithmic style s-curve distributions of effort over time are also common within the project management discipline (PMI 2000). There are also several lifecycle models found within the information systems literature, including strategic information systems management models per Nolan (1973) and Galliers and Sutherland (1991). There are also various incarnations of the systems development lifecycle (Boehm 1988) and the adaptive agile methods (Cervone 2011; Highsmith & Cockburn 2001), although these were covered in some detail Section 2.3.3.

The role of social structures in innovation is advocated by Tuomi (2002) and Avgerou (2001). Tuomi (2002) suggests that innovations are only adopted or diffused when users incorporate them into existing social practices. As a consequence Tuomi (2002) argues that innovation should be studied within its social context. Avgerou (2001) focuses on ICT innovation in the context organisational studies and argues that ICT innovation should be considered in terms the processes related of socio-organisational change, and that research should take into account the intuitional forces within the organisational and the environment.

There are also a number of additional socio-technical perspectives that are relevant to innovation. Geels (2004) and Williams and Edge (1996) demonstrate how socio-technical theory can be integrated into innovation theory to explain innovation activity and innovation cooperation.

The flow of knowledge and the acquisition of technology across different organisations emerged as an issue during data analysis. This phenomenon is well documented in the Management and IT/IS literature. Merali (2002) and later Clarke (2005) introduce the role of permeable organisation boundaries in the context of knowledge management and collaboration. Clarke and Turner (2003) suggest an extension of traditional resource based theory to address the importance of resources utilised beyond the organisational boundary, arguing resources connected via permeable boundaries have the potential to competitive advantage.

Obtaining a deeper understanding of factors that may or may not affect the success of an innovation also emerged as potentially important area of theory. An extensive review of the innovation literature relating to commercial and technological viability of new product innovations has been undertaken by Van der Panne, Van Beers and Kleinknecht (2003). This review argues that various factors can be grouped into firm, project; product and market related factors. Maidique and Zirger (1984) ague that there is no single magical factor that can explain innovation success or failure.

2.7 Chapter summary

This chapter has presented an overview of the literature relating to IT innovation drawn from the parent domains of information systems and innovation theory. Initially an introductory background was provided to set the context of the review and to elaborate on what was being studied and why it was important.

Two parent research domains were discussed in detail:

- First the relevant theory associated with the development, implementation and use of IT was reviewed, highlighting the organisational value of IT, the methods and techniques used for IT design, development and implementation, the sources of knowledge for IT/IS implementation, the industry structures and networks; and the use of innovation diffusion and adoption theory within IT/IS research.

- Second, innovation theory was introduced, providing a contemporary definition for innovation, discussing the important characteristics and dimensions of innovation, and highlighting a consolidated framework used to conduct research in innovation.

The parent domains were then revisited to provide the theoretical framework and research issues associated with the study. This review argued that current understandings of IT innovation in the context of IS theory were fragmented and contrasting. It emphasised the importance and relevance of existing theory, but highlights a number of prevailing issues – (1) limited differentiation of IT innovation from IT development, implementation and evaluation processes; (2) lack of insight into the different ways in which IT innovation occurs in practice, and the factors important in any determination of IT innovation success and/or sustainability; and (3) a prevalence of assumptions that IT innovation can be meaningfully conceptualised through a linear model of staged activities. Several issues worthy of further investigation were also identified whilst comparing the intersections of literature from information systems research and innovation theory.

In concluding, it is proposed that innovation theory offers considerable promise for unifying many of the issues found within IS/IT implementation research. A heuristic model was drawn upon from the empirical guidance found within the Oslo Manual (OECD/Eurostat 2005) in conjunction with high-level characteristics and dimensions innovation found within the broader innovation theory. It is proposed that the heuristic model can be utilised to explore and analyse IT innovation practice and what IT innovation is, how IT innovation is achieved, and how IT innovation can be analysed effectively. Through this process it is anticipated that the heuristic model will be reinvigorated and evolved to contribute to an improved understanding of IT innovation theory and practice. The next chapter provides detailed description of the methodology used to conduct this research.

3 METHODOLOGY

3.1 Introduction

This chapter presents the research design and methods used to conduct this research. It describes and justifies the research philosophy, strategy and the procedures used for data collection and analysis. It also outlines the approach taken for interpretation and discussion, the ethical considerations and reflections on the limitations of this research. The chapter is structured in the following sections:

- Section 3.2 describes the philosophical position of this research. A subjective ontology in combination with an interpretive epistemology was selected to be most appropriate to answer the exploratory research question.
- Section 3.3 outlines the research strategy employed for this research. A multi-case study method was employed in conjunction with a qualitative design to investigate nine case studies of IT innovation practice.
- Section 3.4 describes the procedures used to select cases and collect data. Cases were purposefully selected from organisations involved in the development, implementation and/or use of IT. Cases included organisations from both the IT producer and IT user sectors. Data collection involved the use of semi-structured interviews, documents and field notes.
- Section 3.5 describes the procedures for data analysis. Data analysis was conducted in two stages. Stage one involved an inductive thematic analysis of data from each individual case. Stage two involved a cross-case analysis that identified similarities and differences across cases and organised the results around related themes, social structures and information technology artefacts.
- Section 3.6 describes the techniques employed to interpret the data analysis. The results of the within-case and cross-case analysis were interpreted to produce an empirically grounded model of IT innovation for the case studies. Findings from case studies were then contrasted with the existing literature and used to develop an improved knowledge framework for future IT innovation research.

- Section 3.7 outlines the ethical considerations undertaken as part of this research. A utilitarian approach was adopted focusing on informed consent, the avoidance of harm and the maintenance of confidentiality.
- Section 3.8 concludes the chapter with a summary reflection on the research methodology and the methodological contributions made.

3.2 Research Philosophy

This research is based on philosophical assumptions taken by the researcher about the nature of reality (ontology), and the nature of knowledge and how things come to be known (epistemology). These assumptions have then informed and guided subsequent decisions about appropriate research strategies, methods and procedures used in this research (Chua 1986).

A number of different methods exist for classifying and describing the philosophical assumptions of research. However it should be acknowledged that these methods are subject to considerable variation and debate. This research justifies its philosophical assumptions in terms of ontology and epistemology.

The methodology used in conducting this research adopted a research philosophy with a subjective ontology and interpretive epistemology.

3.2.1 Subjective Ontology

Ontology is concerned with the nature of reality and whether the empirical world is objective and exists independent of humans; or subjective, existing only through human action (Orlikowski & Baroudi 1991).

This research is multi-case study investigation of organisational approaches and experiences in IT innovation. It includes both exploratory and descriptive components (Neuman 2002) that rely upon the meanings people assign to IT innovation, where IT innovation is assumed to influence and be influenced by the social and organisational contexts where it occurs (Walsham 1993). As a consequence this research adopts a subjective ontology, where the empirical world is assumed to be constructed by the action and interaction of the participants and researcher.

3.2.2 Interpretative Epistemology

Epistemology is concerned with the nature of knowledge and how we acquire it (Hirschheim 1992). Epistemology also influences methodology and the implementation of method (Carter & Little 2007). Epistemology is often categorised in terms of a perspective or paradigm. Orlikowski and Baroudi (1991) describe three perspectives common in the context of information systems research – positivist, interpretive and critical. Guber & Lincoln (1994) elaborate and expand the categories at general level to include a fourth perspective – post-positivism, also substituting the term constructivist for the interpretive perspective.

The *positivist* epistemology is linked to an objective ontology, assumes that there is a single objective physical and social reality that exists independent of humans (Orlikowski & Baroudi 1991) and that theories must be verified or falsified in a deductive manner. Positivist research often seeks to discover generalizable knowledge that can be used to predict patterns or behaviours across situations (Guba & Lincoln 1994). In positivist research the researcher seeks to remain independent from the phenomena under study (value-free or neutral). Positivist methodologies are concerned with measuring and analysing causal relationships between variables. Examples of positivist methodologies include controlled experiments and surveys.

The *constructivist or interpretive* epistemology is almost the antithesis of positivism. Constructivism is linked to a subjective ontology, assumes that there is no one objective reality and that reality or truth is constructed socially and experientially through individuals. Thus there exists multiple realities for any particular context and that all realities are equally valid in truth (relativism). It is also assumed that the interpretation of reality can change with context and time. Constructivism emphasises the importance of subjective meaning. Enquiry focuses on interpreting value and meaning and seeks to answer how and why type research questions through interaction or participation within a social context. In contrast to positivism constructivist theory is captured through inductive or emergent mechanisms as opposed to deduction. Within the constructivist paradigm the investigator and the phenomenon or object of study are assumed to be implicitly linked (value-laden). Constructivism does not generalise in the positivistic sense, however it is possible that theory can be transferred from one theoretical context to another in an analytic form as opposed to statistical generalisation (Yin 2013).

The *critical* epistemology or *critical theory* is arguably interpretive and assumes that reality can be understood but that it is historically constructed and that it is produced and reproduced by people (Myers & Avison 2002b). Critical theory also adopts the view that phenomena cannot be viewed in isolation and that various components exist in the context of their relationship with other components (Orlikowski & Baroudi 1991). Critical theory embraces a subjective ontology where phenomena can be understood by the analysis of 'what it has been, what it is becoming, and what it is not' (Chua 1986, p. 601). The role of the researcher in critical theory is to critique of the status quo, reveal contractions and conflicts, and transformation of social, political, ethnic and gender values. Critical theory research typically involves long-term ethnographic and historical studies (Perry, Riege & Brown 1999).

Post post-positivism provides a junction between positivism and constructivism and is alternatively described as realism (Healy & Perry 2000). The realism or post-positivism paradigm acknowledges the existence of a single common reality that is part of a complex open system; independent of any one person that is difficult to fully observe and understand (Wynn & Williams 2012). Contrary to the constructivist perspective, realism views perception not as reality, but as one person's interpretation of reality (Perry, Riege & Brown 1999). Realism's hybrid ontological assumptions link it to an interpretive (constructivist) epistemology whereby knowledge must be interpreted from the value-laden (subjective) realities of actors in a social context. The realist-interpretive perspective views the meanings that people assign to observations and experiences as perceptions of a single independent reality. Perceptions which can then be triangulated with other people's observations and experiences (Healy & Perry 2000). Research conducted under the realism paradigm can be multi and mixed method as researchers seek a reduction of bias through triangulation and alterative perspectives.

Various philosophical perspectives also exist in relation to use of the constructivist epistemology in science and technology studies. Social researchers have widely discussed the role of technology in socio-technical systems. This discourse is often explained in terms of the contrasting theoretical positions of social and technological determinism.

Social determinism proposes that technology is created for and by the needs of society and that there are no "specific effects of technology attributable to its material qualities".

Technological determinism on the other hand proposes that technology is actually the main cause of social and organisational change (Sawyer & Jarrahi 2014).

In early science and technology studies, technological determinism was the dominant paradigm. However a number of alternative theoretical approaches evolved to push back towards the notion of technologies being socially constructed. According to Sawyer and Jarrahi (2014) the most prominent of these approaches where:

- The Social Construction of Technology (SCOT) (Pinch & Bijker 1984) – focuses on how technology was socially, constructed, what problems it solved in a social context, and what meanings were ultimately assigned to the technology artifacts.
- The Social Shaping of Technology (SST) (Wajcman & MacKenzie 1985) – explores organsiational, political, economic and cultural factors associated with the implementation of technology. It also "examines the content of technology and the particular processes involved in innovation" (Williams & Edge 1996).
- Actor-Network Theory (ANT) (Callon & Law 1986; Latour 1987) – pushes for a middle ground by providing equal priority and agency to humans and technological artefacts. Views social structures as "patterned networks of heterogeneous materials" (Law 1992) and examines the formation, dynamics and translation of these networks in the context of actors and their aligned interests.

Where SCOT and SST align well with the subjective ontology and constructive interpretive epistemology. ANT deviates toward the realist ontology and the post-positivism epistemology (critical realism).

This research adopted a constructivist/interpretive epistemology. The interpretive perspective has a high degree of alignment with the subjective ontology.

3.2.3 Justification of the research philosophy

Research employing a subjective ontology with an interpretive epistemology is not uncommon within information systems research or the management science research. Whilst a great proportion of research is conducted following a positivist perspective, interpretive studies are accepted where the methods and techniques used within the natural sciences often fail to yield adequate exploratory insight in to social and organisational phenomena (Lee 1991; Orlikowski & Baroudi 1991).

The aim of this study is to explore IT innovation, what it is, how it is achieved, and how can it be effectively analysed. This research is set within organisational context where interactions occur in a complex behavioural system consisting of people and information technology. Both the context and issues identified within the literature suggest a high degree of alignment with the interpretive perspective that are characterised by – actors in a social context operating in a complex open system, research objectives that are predominately exploratory in nature, the researcher being required to construct an interpretation of behaviours between people and information technology in relation to IT innovation, and involving literature and issues that span multiple theoretical perspectives within information systems and innovation theory domains i.e. there is a requirement for pluralism.

Revisiting the four paradigms described by Guber & Lincoln (1994) and accepting the ontological assumptions of the researcher, the research objectives and the context of this research, the positivism and post-positivism perspectives are deemed unsuitable on the basis of their ontological position. Whilst the positivist perspective outright rejects subjective relativism, it is acknowledged that the layered ontology associated with the post-positivist provides scope to include a constructivist-interpretative epistemology. However the post-positivist perspective still requires accepting a realist perspective that is not aligned with the exploratory and descriptive nature of this research.

Similarly the utility of the socio-technical perspectives discussed in the previous section are acknowledged, but the application of Actor-network theory (ANT) is rejected on the basis of issues associated with general symmetry and its application across a relativist/subjective ontology. On this issue Walsham (1997) suggests that researchers "do not have to accept the full symmetry hypothesis of humans and nonhumans in order to make use of the theory" and that ANT "can be complemented by other social theories which take better account of broader social structures". Hence the methodology adopted in this research seeks to incorporate a number of the socio-technical perspectives found in SCOT, SST and ANT, albeit in a manner more closely aligned to the subjective-interpretive paradigm (see section 3.3.2.6).

Both the constructivist/interpretive and critical theory perspectives implicitly accept subjective relativism and the epistemological position that knowledge is obtained by interpreting value and meaning through interaction or participation within a social context (Guba & Lincoln 1994). This position is closely aligned to the exploratory and descriptive purpose this study.

The constructivist/interpretive perspective places the researcher in an orchestrator or facilitator role constructing meanings associated with experience (Guba & Lincoln 1994). Critical theory places considerable emphasises on the historical construction and transformation of reality and pushes the researcher to reconstruct previously held beliefs about the status quo. Whilst there are elements of critical theory that align with the research objectives, it places too great an emphasis on the authority of the researcher. Conceivably such authority diminishes substantially where the researcher does not experience specific events or the instances of IT innovation themselves.

3.3 Research Strategy

Research strategy refers to the way in which different research designs, methods and techniques are organised to meet the research objectives. Cavaye (1996, p. 227) defines research strategy as 'a way of going about one's research'. This section describes and justifies the use of case study research as the primary research strategy employed by the research. It then describes and justifies the use of a multiple case study design in conjunction with conjunction with qualitative research methods and techniques.

3.3.1 Case study research

Yin (1981) describes the case study approach as a research strategy. There is considerable discussion and debate regarding the methodological positioning of case study research. This research adopts the contemporary perspective of case study research encompassing the logic of design, and the techniques for data collection and analysis (Patton 2002; Yin 2013).

Case study research invariably involves one or several case studies. Stake (1995) suggests a case study represents the researchers choice of what is to be studied. Merriam (2014) defines a case study as an in depth description and analysis of a bounded system'. Merriam (2014) also describes qualitative case studies as being focused on a particular situation, event or phenomenon (particularistic), where the end product becomes a thick description of the phenomenon under study (descriptive), and where the readers understanding of the phenomena under study is expanded (heuristic).

Case study research may be exploratory, descriptive or explanatory and Yin (2013) suggests that 'you use the case study method because you want to understand a real-life phenomenon in depth, but such an understanding encompassed important context conditions, because they were highly pertinent to your phenomena of study'.

Case study research can also play an important role in advancing knowledge in a particular research theme or domain (Merriam 2014). Case study research provides a close link with the empirical setting and as a consequence it can be particularly useful for building theory (Eisenhardt 1989b). Unlike experimental research that seeks to remove phenomena from its context, and survey-based methods that have limited ability to investigate context, case study research seeks an in depth investigation of phenomenon within its real-life context (Yin 2013).

For the qualitative researcher case study research has particular strengths that make it an extremely pervasive research strategy in many business and information systems research studies. At a philosophical level case study research is closely aligned to research utilising a subjective-interpretive philosophy, however case study research need not be either (Walsham 1995).

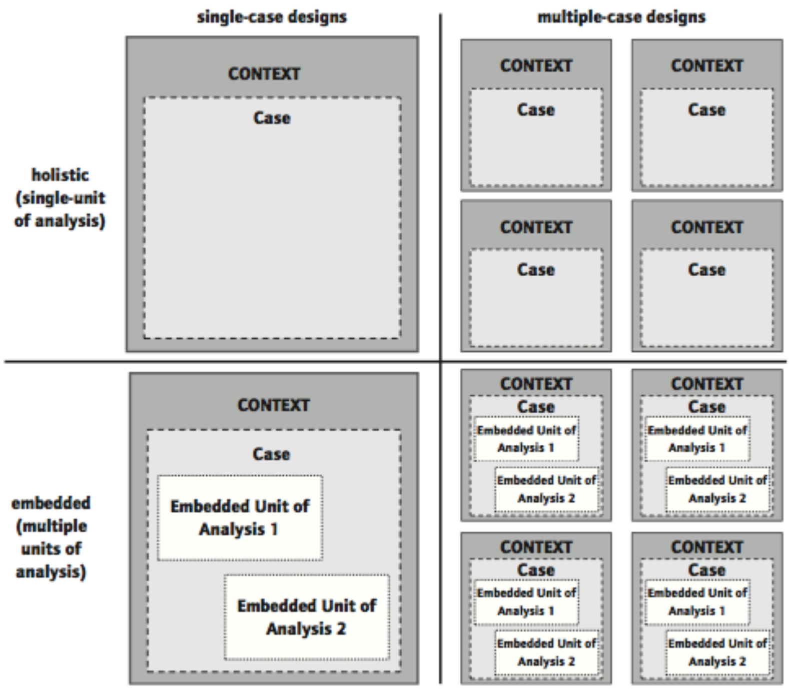
3.3.1.1 Multiple case study design

Yin (2013) uses the term "multiple case study" to describe case study research design involving more than one case. Elsewhere in the literature multiple case study designs can be also be referred to as multi-case, multi-site, collective or comparative case studies (Merriam 2014).

Yin (2013) delineates between different types of basic case study design on the basis of whether it involves one or multiple cases, and then whether each case has one (holistic) or multiple (embedded) units of analysis. Yin (2013) illustrates the design variants as a matrix (see figure 3-1) comprising four types: (1) the single case holistic design, (2) single case embedded design, (3) multiple case holistic design, and (4) multiple case embedded design.

There are of course all manner of variations upon this scheme. Yin (2013) is also sensitive to the notion case study design will invariably ‘include a desire to analyse the contextual conditions in relation to the case’.

Figure 3-1. Four basic types of case study design (Yin 2013).



This research adopts a multiple-case design exploring cases of IT innovation in the organisational context. The decision to include one or more cases is important for case study research design (Benbasat, I, Goldstein, K & Mead, M 1987).

Multiple case study designs are applicable to research that involves description, theory building or theory testing (Benbasat, I, Goldstein, K & Mead, M 1987). Multiple case study designs also allow researchers to conduct cross-case comparison of data from different sources. From an interpretivist perspective this opens up the options to develop and refine concepts for further study, and allows concept to be evaluated in different contexts (Darke, Shanks & Broadbent 1998). Thus a multiple case study design is highly suitable for extending existing theory (Benbasat, I, Goldstein, DK & Mead, M 1987).

The selection of a multiple case design has implications for the data collection, analysis and interpretation procedures used in this research. The use of multiple case studies as opposed to a single case requires an appropriate selection procedure covering the number, type and method of selection for cases. Case selection procedures are described and justified in Section 3.4.2. The sequence and protocols for data collection must also reflect dealing with multiple cases. Data collection procedures are described and justified in Section 3.4.3. Multiple case study design also introduces the option of cross-case analysis, either in conjunction with or following on from a within-case analysis. Procedures describing and justifying the data analysis are provided in Section 3.4.4. Having multiple cases also impacts the discussion and interpretation of the research findings. How the researcher justifies the applicability and context of theory from the particular to the general is outlined in Section 3.4.5.

3.3.1.2 Limitations of case study research

Case study research is subject to various criticisms ranging from the philosophical to the practical. At a philosophical level case study research is closely aligned to research utilising a subjective-interpretive philosophy and issues associated with (1) a lack of empirical generalisability, (2) research bias, and (3) rigour and reliability are often cited as limitations related to case study research.

Case study research is often criticised for its lack of generalisability. Valid research seeks to extend the scope of its findings beyond the empirical context. It is commonplace in positivist research to have scientific facts established via multiple sets of experiments that replicate phenomena under different conditions (Yin 2013). The main purpose of this replication is to establish external validity and statistically generalise from the empirical context to the broader population. It would be rare if not problematic for case studies to represent randomly selected samples aiming to statistically generalise findings to a given population (Cavaye 1996; Yin 2013).

Despite the statistical limitations associated with case study research, it is possible to generalise the findings of cases studies to theory. This mode of generalisation is distinctly different in purpose, Yin (2013) describes the process as analytical generalisation whilst Stake (1995) describes the process as naturalistic generalisation. Lincoln and Guba (1985) propose a concept of transferability over generalisability and suggest the researcher must make the research process explicit when presenting their research. The technique specified by

Lincoln and Guba (1985) to allow the reader to judge the transferability of research into other contexts is to provide a thick description. This research has employed detailed presentation of the context and findings for each case and for the cross case analysis.

Researcher bias is also a common criticism of case study research. Where qualitative methods are employed the case study method is likely to involve subjective judgment on the part of the researcher (Flyvbjerg 2006). Thus the researcher's background and experiences can affect the process of case selection, data collection and interpretation of the data (Yin 2013). Whilst researchers working with a positivist objective epistemology seek to remove such influences or bias, arguments can be made that this influence is an essential component of the subjective interpretive empirical domain. Eisenhardt (1989a) for example suggests that the process of reconciling contradictory or paradoxical evidence from cases actually unfreezes the thinking of researchers and that this in turn leads to theory that is generated with less bias than research built purely from deductive methods. Both the researcher and participant face this limitation in the empirical context, an issue that is acknowledged and embraced by this study.

The researcher can also influence responses from participants during data collection. The participant's reaction to the interviewer and interview process can introduce bias. For example the length of the interview, the emotional demeanor of the interviewer or interviewee, the types of questions, and the interview setting itself can all contribute to possible research bias. To address this type of bias the researcher endeavored to collect case data from multiple sources of evidence (Miles & Huberman 1994).

The third major criticism of case study research is that it lacks rigour and reliability. Yin (2013) argues that a lack rigour in case study research may be symptomatic of there being no standardised set of methods or procedures for conducting case studies, something that Yin (2013) and other researchers have arguably set out to remedy. To address the issue of rigour and reliability Yin (2013) advises researchers that they should make as many steps in the research processes as operational as possible, and have multiple researchers conduct each case. The institutional arrangements for this research prevent the use of multiple researchers conducting each case study, however open and transparent techniques that detail the research procedures used in this research are reported in Section 3.4 of this chapter and in Chapters 4 and 5. This research has also followed the guidance for quality and credibility set out for interpretative field studies by Klein and Myers (1999). A synopsis of how this guidance has been applied to this research is provided in Section 3.5.

At a practical level researchers have identified several limitations that sometimes make case study research difficult or unsuitable for specific investigations. For example case study research can be time consuming and complex (Darke, Shanks & Broadbent 1998). Yin (2013) suggests that complexity in the description and reporting of case studies can be addressed through innovative adjustments to methodology. However for the qualitative researcher, case study research has particular strengths that make it an extremely pervasive research strategy in many business and information systems research studies.

3.3.1.3 Justification case study research approach

The case study approach is particularly relevant to the interpretative-epistemology, where the investigator in the empirical context the must analyse data based on the interpretation of participants who have experienced or observed events (Easton 2010; Perry 1998). In this context, case study research provides a close link with the empirical setting and as consequence it is particularly useful for building theory. Unlike experimental research that seeks to remove phenomena from its context and survey-based methods that have limited ability to investigate context, case study research seeks an in depth investigation of phenomenon within its real-life context (Yin 2013). Case study research is also useful for extending research where the existing body of theory may be inadequate (Eisenhardt 1989b).

The case study research strategy was primarily selected for this research because the purpose of the research was to explore and describe complex contemporary phenomena, where the research question was seeking a detailed understanding of IT innovation. Rosenberg (1994) for example suggests that to understand innovation beyond more general concepts inevitably involves drilling down into the domain to examine the common patterns and cases. The case study research strategy is also widely accepted within the information systems and management science disciplines as being relevant and valid for research (Cavaye 1996; Jans & Dittrich 2008; Ravenswood 2011).

Many of the criticisms of case study research that are consequently labelled limitations lie more with the interpretative epistemological stance and the use of qualitative methods. For example, the case study literature discusses issues of generalisability, research bias, rigour and reliability that are invariably linked to the subjectivity of the investigator and other participants. These arguments are addressed, but not dismissed by Yin (2013), however Stake (1995) and Merriam (2014) see concepts such validity and reliability as being positivistic constructions and impossible to apply the in the context of an interpretative-qualitative research (Yazan 2015). For the interpretive-qualitative researcher these are not limitations at all, but features of the research strategy to be embraced and utilised to answer research questions (Merriam 2014).

Thus an alternative approach for interpretive researchers is to embrace principles of research quality derived from interpretive perspectives (Stake 1995). Klein and Myers (1999) provide one such scheme that is particularly relevant to qualitative fieldwork in information systems and addressed in the context of this research strategy in the following Section (3.3.2).

3.3.2 Qualitative research

Research methods are routinely classified as using qualitative or quantitative methods (Myers & Avison 2002a). Qualitative designs focus on methods of data collection and analysis that facilitate in depth understanding of phenomena through the perspectives and behaviours of participants in social settings, where quantitative designs focus on measurement. Qualitative techniques allow the researcher to collect data from individuals that have experienced or observed events associated with the phenomena under study. Qualitative methods also provide inductive analytical options that allow the researcher to construct interpretive models of the phenomena under study.

Flick (2002) describes four essential features for conducting qualitative research:

(1) Appropriateness of methods and theories – select the most appropriate methods and theory to investigate the phenomena under study.
(2) Perspectives of the participants and their diversity – research must take into account the subjective perspective of participants and recognise that their viewpoints and practices may be different, even in the same context.

(3) Reflexivity of the researcher and the research – the researcher is considered an explicit part of knowledge production. They must recognise and reflect upon their role in the research.

(4) Variety of approaches and methods – Research should embrace the variety of approaches and methods available within the qualitative tradition and not be overtly based on unified theoretical and methodological concepts.

This research involves a multiple case study design conducted within a subjective-interpretive research paradigm. Qualitative techniques are routinely employed to conduct case study research conducted under interpretive epistemology. Qualitative methods are also widely accepted as appropriate for information systems research (Benbasat, I, Goldstein, DK & Mead, M 1987; Dubé & Paré 2003; Lee 1989) and management research (Eisenhardt 1989b; Eisenhardt & Graebner 2007). There is also widespread use of qualitative methods within the innovation literature (Barras 1986; Hargadon & Sutton 1997; Slaughter 1993; Sundbo 1997).

The recording and analysis of the subjective perspectives of key personnel within each case was critical to the conduct of this research. The reflective accounts of participants closely involved in IT innovation were recorded, transcribed and then analysed using inductive techniques in order to interpret meaning. The code and themes developed during this analysis were closely linked to the data in order to preserve the subjective perspective of the participant (Boyatzis 1998). The qualitative techniques used in this process are described in detail in section 3.4.4.

Walsham (1995) identifies two different roles for the interpretative researcher – the involved researcher and the outside observer. The involved researcher engages the research from within, either as a participant observer or action researcher. The involved researcher may influence participants, the context and may also interact directly with the phenomena under study. Conversely the outside observer maintains distance from the participants and does not directly participate or influence the context or interact with the phenomena. Valid arguments persist for both roles in interpretative studies. The outside observer approach can facilitate open and frank discussions during interviews that are not necessarily constrained by time and location. However sensitive or confidential data may be restricted or blocked from the outside observer because they are not considered part of the organisational context. The involved researcher on the other hand, may get access to important insights and information by virtue of their close involvement with the organisational context. However they may also struggle in their interactions with the participants when they are seen as having a stake in the outcomes, as some participants may be somewhat guarded discussing their experiences.

This research is concerned with IT innovation, how IT innovation decisions were made and how IT innovation evolved over time. Whilst the organisational cases of IT innovation were contemporary, most had histories spanning several years. The self-reported experience of participants via interview was considered most appropriate method to collect data in these circumstances. Thus the role of the researcher adopted for this study is that of an outsider-observer.

There is considerable variety in qualitative inquiry. Patton (2002) distinguishes between sixteen traditions (or orientations) of qualitative inquiry. Within and across the various traditions of inquiry a range of methods and techniques are employed in the conduct of research. This research utilises a number of qualitative techniques to collect and analyse data. Data was collected using semi-structured interviews complemented by field notes and organisational documents relating to the cases. Data was analysed using inductive theory building techniques within and across cases. The existing literature was evaluated prior to analysis and used to establish the research issues to shape research questions. During analysis, emergent theory was compared and contrasted with existing literature.

3.3.2.1 Studying conversation

Conversations are a rich and indispensable source of knowledge (Brinkmann 2013). Various methods can be employed to build knowledge from conversations. These methods are encapsulated within the concept of an interview. An interview allows the researcher to enter into perspective of another person (Patton 2002) in a process of exchanging views (Brinkmann 2013).

Patton (2002) describes several variations of the interview process routinely employed in qualitative research. These variations can be summarised as being structured, unstructured and semi- structured. Structured interviews comprise a set of standardised questions. Questions may be open ended or closed with a fixed response. In effect the same questions are presented to each participant. Conversely unstructured interviews follow the format of an informal conversation with no predetermined questions where different information will be obtained from each participant. Sitting between the two extremes is the semi-structured interview, where the interview is guided by important research issues without completely constraining the participant. Questions may be asked but only to focus conversation on key high level issues.

Like all methods each has its strengths and weaknesses. Structured approaches have the capacity to simplify data analysis, but they may also limit and constrain the participants, particularly in closed fixed response type interviews. Unstructured approaches offer greater if not maximum flexibility, but they can become difficult to analyse. Unstructured approaches are possibly better suited to single cases or ethnographic research. The semi-structured approach provides the middle ground between flexibility and constraint of the participant, keeping interactions focused whilst allowing for individual perspectives to emerge.

The primary data collection method used in this research was the semi-structured interview. The interview guide along with the procedures employed for this research is described in section 3.4.3.

The quality of information obtained from interviews is dependent on the interviewer (Patton 2002). Beyond the skills gained through experience, the interviewer can employ a number of supporting tools and techniques to improve the quality of qualitative interviews:

- Interviews can be recorded and transcribed – audio recording and transcription offer the best opportunity to preserve the interview for analysis (Merriam 2014).
- Researchers can take field notes during and after interviews (Bogdan & Biklen 2006) – field notes can capture descriptions and the researchers' reflections of conversations and add clarity in analysis.
- Use probes (Bogdan & Biklen 2006) – 'neutral questions, phrases, sounds, and even gestures interviewers use to encourage participants to elaborate on their answers' (Mack et al. 2005, p. 1).
- Avoid leading questions – influential questions that may bias a participant response or line of thinking (Mack et al. 2005).

- Interview data can also be supported by secondary data – text and related material can assist in establishing perspectives and assist to substantiate the quality and reliability of the meanings inherent in the text (Chau 2002a).

3.3.2.2 Field notes

Field notes represent another technique for qualitative data capture. Field notes are used intensively in participant observation studies but they can also be used to record data from interviews. When used in conjunction with interviews field notes can provide a substitute for audio recordings and transcription. Alternatively they can be used to complement recorded interview data in an initial overlap of data collection and analysis (Eisenhardt 1989b). Used in this fashion field notes provide the researcher with an opportunity to further describe context or reflect on issues and observations during data collection (Bogdan & Biklen 2006). Field notes are also useful for future detailed analysis and possible review in support of transcription and/or coding.

Loflan et al 2006 suggests there are two generic forms of field notes – descriptive and reflective. With descriptive field notes the investigator attempts to provide an account of the interview context covering off on the actors, conversations and themes covered during the interview. Where with reflective field notes the investigator records their thoughts, ideas, questions and concerns.

When used in conjunction with interview field notes should be written as soon as possible following the interview (Lofland & Lofland 2006).

This research used descriptive and reflective field notes in support of recorded and transcribed interview data.

3.3.2.3 Secondary data sources

Secondary data sources represent data associated with the phenomena or case under study that was not collected by the investigator. In qualitative studies secondary data can sourced from a wide range and variety of sources. Examples include text, documents, multimedia and related archives. Secondary data can significantly enrich qualitative studies, although it has considerable potential for error and bias (Lofland & Lofland 2006).

There are various combinations and applications for secondary data that fit with a range of research designs. One important application of secondary data is its use to verify and substantiate the quality and reliability of interview data (a form of triangulation).

This research employs the use of secondary data, primarily in the form of organisational documents and records that are used to verify and substantiate the quality and reliability of interview data.

3.3.2.4 Inductive theory building

Theory consists of 'plausible relationships proposed amongst concepts and sets of concepts', where concepts can be defined as general propositions used provisionally as principles of explanation for a given phenomenon (Strauss & Corbin 1994, p. 273).

Theory building is the process of generating theory, describing concepts and relationships for a given phenomenon. Theory can be built following a deductive or inductive approach. The deductive approach commences with abstract thinking and then seeks to connect theory to observations (evidence) through a process of testing. The inductive approach effectively reverses the direction, taking detailed observations and using them to generate theory, and linking theory to abstract ideas (Patton 2002). Inductive theory building techniques are closely aligned to the interpretative epistemology where the researcher attempts to extract meaning from the experiences of participants in order to describe and explain phenomena (Creswell 2013).

Using an inductive approach to build theory requires different methods and techniques for data collection, analysis and interpretation than would be employed for a deductive approach. Data collection must contain rich descriptions of observations in the field. Transcribed interviews, field notes and secondary data collection provide an ideal base for this. The methods of analysis and interpretation require the means to evaluate and categorise meaning, moving from the detail to the abstract. These methods must also provide the means to adequately communicate understandings of the phenomena to an audience. There are a wide variety of inductive techniques that can be used and adapted for inductive theory building. Braun and Clarke (2006) cautions that some of these methods and techniques are tied to a particular theoretical and epistemological positions, and advocates for the adoption of methods that are independent of such.

Miles and Huberman (1994) provide a comprehensive guide to qualitative data analysis techniques. It also describes and consolidates the various techniques into activity/process groups that are involved – data reduction, data display, and drawing conclusions. Data reduction being the simplification and transformation of data from research artefacts such transcriptions and field notes. Data reduction assists with the other activities, data display and drawing conclusions. Inductive coding is an example of a data reduction activity. Data displays involve structuring and organising data to facilitate conclusion drawing. Miles and Huberman (1994) describe four generic types of data display – partially ordered, conceptually ordered, case ordered and time ordered, along with various extensions such as partitioning and clustering. Examples of data displays include matrices and network maps. Finally, drawing conclusions involves noting patterns, similarities and differences in the data, describing the concepts and relationships between concepts and building theory.

The literature varies as to how approach the inductive analysis of case study research comprising multiple cases. Miles and Huberman (1994), Eisenhardt (1989b) and Yin (2013) all describe a two phase within-case and across-case analytical process to be used with multiple case studies. This research adopts the approach of Miles and Huberman (1994) where data reduction, data display and drawing conclusion activities are conducted over two phases of data analysis, one concerned with within-case analysis and the other across-cases analysis.

3.3.2.5 Use of existing literature

The role of existing theory in interpretive-qualitative research is different from its use in positivist-quantitative research (Creswell 2002). Even within the interpretive-qualitative domain the use and purpose of existing theory varies with different methodologies.

Researchers access existing theory through the research and related literature. The positivist-quantitative researcher will conduct an extensive examination of the literature at both the beginning and the end of a study. At the beginning of a study prior theory is used to justify the importance of the research and to develop the rationale for the research question(s) and hypothesis. At the end of the study the positivist-quantitative researcher seeks a comparison of the results with the predications found within the existing theory (Creswell 2002).

Depending on the adopted methods, the interpretive-qualitative researcher may use prior theory within the existing research literature to justify the study, but they will not typically discuss the literature at the beginning of study. The interpretive epistemology that drives interpretive-qualitative research prioritises the views of the participants over and above the views contained with the literature. It sees prior theory as a risk or ideological hegemony that potentially constrains new concepts and propositions that may emerge directly from subjective experiences (Maxwell 2012). Grounded theory researchers (Glaser & Strauss 1967; Glaser 1978; Strauss & Corbin 1990) have been the most influential in advocating the view 'that theory is grounded in the actual data collected, in contrast to theory that is developed conceptually and then simply tested against empirical data' (Maxwell 2012, p. 215).

Where the objective of the research is to extend or modify existing theory, the interpretive-qualitative researcher may use prior theory to support the findings. The critical difference being interpretive-qualitative research is not about 'making predications about findings, but more interested if the findings support or modify existing ideas and practices advanced in the literature' (Creswell 2002).

The use of prior theory towards the end of a study, during the analysis and interpretation phases is advocated by Eisenhardt (1989b) and described as enfolding the literature. (Eisenhardt 1989b, p. 544) explains that this process involves 'asking what is this similar to, what does it contradict, and why'. Eisenhardt (1989b) also suggests that researchers should consider a broad range of literature. Walsham (1995) points out that this view would be unacceptable to many interpretive researchers, but emphasises that theory is an acceptable and desirable output of case study research and that it is possible to access existing theory without 'being trapped in the view that it represents final truth in that area'. In effect enfolding the literature becomes the subjective interpretation of the research findings discussed in the context of prior theory (Ponelis 2011).

This research utilises the existing literature at the beginning of this study to justify the research and to identify research issues and problems associated with IT innovation in the context of information systems research and innovation theory. The literature is then utilised to develop a heuristic model to plan and guide data collection, a type of scaffolding to setup the research that is subsequently discarded during preliminary analysis (Merriam 2014).

During preliminary analysis the focus is on capturing the views of the participants over and above the views contained with the literature. During the later part of analysis and interpretation, findings are compared and contrasted with the existing literature to modify and extend understandings of IT innovation.

3.3.2.6 Quality and credibility in qualitative research

All research is subject to limitations and weaknesses that threaten the quality and credibility of its findings. Unlike quantitative research that seeks to control and eliminate those threats, qualitative research seeks to understand and use them productively (Maxwell 2008).

The quality and credibility challenges associated with qualitative research primarily revolve around the selected research paradigm and the investigators ability to create a convincing argument about how they arrived at the findings. Much of the controversy associated with qualitative research concern doubts about the nature of the analysis, which is highly dependent on the insights and conceptual capabilities of the analyst (Patton 1999).

Healy and Perry (2000) suggest that the quality of research should be judged on the basis of the research paradigm i.e. the ontology and epistemology and method. Within the qualitative tradition Patton (2002) outlines at least five contrasting sets/schemes of criteria used for judging quality and credibility of qualitative research – traditional scientific research, social construction and constructivist, artistic and evocative, critical change, evaluation standards and principles.

Klein and Myers (1999) provide seven principles (see Table 3-1) to assist researchers address many of limitations associated with interpretive field research in information systems. This guidance is routinely applied within the information systems research domain (Cardoso & Ramos 2012).

Table 3-1. Seven principles for conducting and evaluating interpretative field studies extracted from Klein and Myers (1999).

Principle	**Guidance**
1. Principle of Hermeneutic Circle	This principle suggests that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all the other principles.
2. Principle of Contextualisation	Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged.
3. Principle of Interaction Between the Research and Subjects	Requires critical reflection on how the research materials (or data) were socially constructed through the interaction between the researchers and participants.
4. Principle of Abstraction and Generalisation	Requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action.
5. Principle of Dialogical Reasoning	Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ('the story which the data tell') with subsequent cycles of revision.
6. Principle of Multiple Interpretations	Requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts even if all tell it as they saw it.
7. The Principle of Suspicion	Requires sensitivity to possible biases and systematic distortions in the narratives collected from the participants.

At the core of Klein and Myers (1999) guidance is the principle of the hermeneutic circle. Hermeneutics is concerned with the discovery of meaning through the interpretation text. The hermeneutic circle is a mode of analysis that advocates understanding meaning within text through a process of moving back and forth from the specific to the general, stressing the value of context (Myers & Avison 2002a). The other six principles provided in Klein and Myers (1999) guidance relate back to this core principle.

Klein and Myers (1999) recommend that these principles be used to orientate the conduct of research, or to provide a means for evaluating interpretive research after it is complete. They do not recommend that researchers mechanistically apply these principles in their research, rather that researchers reflect on the principles and how they may be useful to a specific study (Cardoso & Ramos 2012).

The interpretive and qualitative nature of this research, combined with study of conversations, the use of field notes and the use of secondary data makes Klein and Myers (1999) principles particularly relevant to this research. As a consequence the principles have been incorporated and reflected upon throughout the data analysis and interpretation phases.

3.4 Research Procedures

3.4.1 Theory development

Eisenhardt (1989b) defines a process for building theory from case study research. This process is described in Table 3-2 along with a description of how the activities align with the process used in this study.

Table 3-2. Eisenhardt (1989b) theory building case study research process in the context of this study – adapted from Urquhart (1999) and Chau (2002b).

Step	**Activity**	**Process used in this study**
Getting Started	Definition of research question Possibly a priori constructs	Conducted a review of the literature across the domain of information systems research and innovation theory. Defined a research question. Constructed a high level heuristic device from the literature that was used to guide data collection and analysis.
Selecting Cases	Neither theory nor hypotheses. Specified population Theoretical, not random, sampling.	Nine organisational cases were purposefully selected from organisations involved in the development, implementation and/or use of IT as part of self-reported IT innovation. Cases selected to maximise the opportunity to explore variation in approach and experience (Patton 2002).
Crafting Instruments and Protocols	Multiple data collection methods Qualitative and quantitative data combined Multiple Investigators.	Semi-structured interviews and field notes. Conversations were recorded and transcribed as qualitative data. Institutional limitation associated with PhD scholarship constrained the research to a single investigator.
Entering the Field	Overlap data collection and analysis including field notes Flexible and opportunistic data collection methods.	Data collection via semi-structured interviews, and field notes and supporting documents. Overlapping data collection an analysis within but not across cases. Follow-up interviews conducted in instances where clarification or additional information was required.

Step	Activity	Process used in this study
Analysing Data	Within-case analysis Cross-case pattern search using divergent techniques.	Two stage within and then cross case data analysis conducted. First stage within case analysis employed inductive thematic analysis. Second stage cross case analysis following the analytical approach advocated by Miles & Huberman (1994). Similarities and differences across cases were identified and organised using meta-matrices structured around related themes, social structures and information technology artefacts.
Shaping Hypotheses	Iterative tabulation of evidence for each construct Replication, not sampling, logic across cases Search evidence for why behind relationships.	Used cross case analysis to derive an empirically grounded model of IT innovation.
Enfolding Literature	Comparison with similar literature.	Revisited the literature in the context of the empirical model to evaluate support, contractions and gaps in the existing theory.
Reaching Closure	Theoretical saturation when possible.	Eisenhardt (1989b) describes two issues reaching closure – when to stop collecting data and when to stop iterating between theory and data (analysis and interpretation). Data collection reached closure after nine cases and at a point where the complexity of the data was reaching the limits of manageability given the constraint of using a single researcher. Interpretation and analysis reached closure when the researcher had generated a conceptual (knowledge) framework from the empirical model and the existing theory that would serve as useful tool for future research.

3.4.2 Case Selection

This research adopts a multiple-case design exploring cases of IT innovation in an organisational context. The reason for selecting a multi-case study approach was not to derive inferences about a large population but to generalise back to theory. This research is exploratory in nature and the case studies utilised for this research were purposefully selected to maximize the variation of context (Patton 2002). This strategy aligns well with research that is of a descriptive and exploratory nature.

Maximum variation case selection is the preferred case selection mode for interpretive-constructivist inquiry (Guba & Lincoln 1994). Themes and findings emerging from the case studies take on added importance at the theoretical level because they emerge from variation

(Patton 2002). Theory arising from this research may also be transferable to other contexts and could be tested for statistical generalisability if that was considered important or necessary in future investigations (Cavaye 1996).

Variation was achieved in this study by selecting organisational cases where there were different types of innovation, different areas of application, and different organisational contexts, including organisations of different size, geographical scope and primary business activity.

Innovation involving either the application or production of IT has also been reported as very pervasive, extending beyond the IT producing sectors into most non-IT producing (IT user) sectors of the economy (Smith, O'Brien & Jerrim 2007). Four cases were selected from the IT producing sector and five from the IT user sector. The maximum variation approach was maintained across these groupings and primarily undertaken to allow the researcher to explore potential similarities and differences across these groups. This approach to is advocated by Yin (2013) and Eisenhardt (1989b) to improve case study reliability and credibility. However the primary utility of this approach for this study was to allow the researcher to explore issue associated with limited differentiation of IT innovation from IT development, implementation and evaluation processes with the literature identified in Chapter 2, Section 2.5.

Nine cases were purposefully selected from organisations involved in the development, implementation and/or use of IT as part of self-reported IT innovation. A summary of the selected cases is presented in Table 3-3.

Table 3-3. Profile and summary of selected cases

Case	Description	Number of Participants Interviewed	Innovation Type +	Innovation Timeframe (Years)	Organisation Context			
					Geographical Scope	Size (FTE)	Primary Business Activity	IT Producer or User
1	Retail software development.	1	Product-Process	10+	National	100 - 249	Retail Sales	User
2	Mobile sales ordering system.	2	Product-Process	5	Regional	20-49	Wholesale Distribution	User
3	Aquaculture production control software.	1	Process-Product	10	National	250+	Aquaculture	User
4	Tourism online sales and inventory middleware.	1	Process-Marketing	3	Regional	250+	Tourism and Accommodation	User
5	Application of LIDAR in forestry resource management.	1	Process-Organisational	10+	Regional	250+	Resource Management	User
6	Healthcare medication management software.	1	Product	7	National	5-9	E-Health Software	Producer
7	Interactive multimedia development in community health.	2	Process-Organisational	10+	National	1-4	E-Health Services	Producer
8	Commercialisation of virtual printer software.	1	Product-Marketing	10+	Global	1-4	IT Systems Integration Services	Producer
9	Gamification application for enterprise social networks.	1	Product	2	Global	20-49	IT Systems Integration Services	Producer

+ Generic types of innovation as defined in the Oslo Manual(OECD/Eurostat 2005). Expressed as *primary-secondary* (where relevant).

Organisations ranged in their size and scope of operation. Organisational size ranged from small micro businesses (1-4 FTE) to larger SME style business (250+ FTE); and operational scope spanned regional, national and global contexts. Cases were also selected from both the IT producing sector and the non-IT producing (user) sectors. Absent from the portfolio selected cases were large multinational companies and globally significant IT companies (Big IT). This limitation is highlighted in Chapter 7, Section 7.4.1.

There is no precise rule as to the number of cases required to progress qualitative multiple-case designs (Patton 2002; Perry 1998). Perry (1998) cites guidance from other researchers and concludes a minimum of 2 to 4, and a maximum of 10, 12 or 15 cases should be developed. Patton (2002) suggests that the number of cases is dependent upon the purpose of the study, 'what will be useful, what will have credibility, and what can be done with the available time and resources'. Hence the term 'purposeful sampling' (Patton 2002).

The unit of observation selected for this research were key personnel associated with the organisation, who were closely involved with IT innovation activity. In most cases a single participant was selected to provide an account of the IT innovation. Where there was substantial specialisation or external sourcing multiple participants were utilised to provide an adequate account of innovation activity.

3.4.3 Data Collection

Data associated with organisational cases of IT innovation were collected using semi-structured interviews (Patton 2002). A semi-structured approach was favoured in order to focus conversation on high level issues associated with IT innovation. This semi-structured approach also helped to avoid constraining participant responses to issues derived from prior theory, and allowed individual perspectives to emerge from the interviews. From a quality and credibility perspective the semi-structured approach was considered to address Klein and Myers (1999) principle 'interaction between the research and subjects' and the principle of 'abstraction and generalisation'.

Per the case selection process (see previous section), interviews were conducted with stakeholders who were directly involved with IT innovation specific to a case study. In seven of the nine cases a single participant was utilised for interview. In the remaining two cases two participants were utilised (see Table 3-3).

In many cases the use of multiple participants for interview was impractical due to the scope and context of this research i.e. the in-depth nature of interviews, along with the availability and access to multiple participants. It is acknowledged that relying on a single informant to reconstruct historical accounts of events and processes can be problematic in terms of participant bias and random error (Kumar, Stern & Anderson 1993), however potential utility of rich and detailed data typically provided by in-depth interviews was seen as an acceptable trade-off.

To address the issues of participant bias and error associated with using single informants the following tactics were employed:

- Participants were purposefully selected on the basis of being “able and willing to share their knowledge with the researcher and occupy such a role that makes them well informed about the issues being researched”(Wagner, Rau & Lindemann 2010).
- Probes were employed during interview to facilitate recall when gaps were potentially apparent per Bogdan and Biklen (2006).
- Interview data was triangulated with secondary data (documents) to corroborate statements made in interviews (Yin 2013).

Interviews were guided by an interview protocol derived from the theoretical framework and heuristic device described for this research in Section 2.4. The interview was protocol designed to generate insight into the antecedents, behaviours and consequences of IT innovation and is described in Table 3-4below.

Table 3-4. Case study interview protocol

Phase	**High level data collection questions**
Antecedents	The decision to innovate Collect information that provides insight into the reasons, motivations and/or objectives driving the IT innovation. Seek to answer – “why did they choose to innovate with IT?”

Phase	High level data collection questions
Behaviours	Innovation activity Record details of scientific, technological and commercial activity that contribute or were intended to contribute to the implementation the IT innovation. Include activity associated with: • Research and experimental development – IT design and development along with the methodologies, processes and techniques used. • The acquisition of capital goods and services – understand the role of the IT artefact and any associated complementary IT assets and services. • The acquisition of external knowledge – explore linkages with other organisations and innovation systems in terms of their contribution to knowledge and the development of the IT innovation. • Activities associated with implementation and deployment, including marketing or internal change management initiatives. Seek to answer – "how did they innovate with IT what social structures and IT artefacts where involved?"
Consequences	Innovation outcomes Record details pertaining to the economic and social outcomes associated with IT innovation. Seek information about the success or failure of IT innovation activities, the realisation of benefits, and any outcome-based dimensions such as changes in organisation performance, degree of novelty and breadth of diffusion. Be conscious of the firm effects associated with IT innovation and how they contribute to success or failure. Seek to answer – "what were the consequences of the IT innovation?"

The interview protocol comprised guidance and a number of high-level questions to focus the participant response within the research domain. However the interview protocol was applied indirectly during participant interviews. Participants were initially asked to describe the IT innovation and tell the story of how it developed. The investigator employed probes (Bogdan & Biklen 2006) to keep the conversation flowing and were interrupted only to clarify or elaborate elements of the conversation. Elements of the protocol were checked off as they were covered in the conversation. Where protocol elements where missing or not covered in detail, further probes were used to facilitate but not force responses. For example, where probes for missing protocol elements resulted in short, limited responses from the participant the investigator simply moved the conversion along.

For all participants the interview process was an in-depth conversation lasting between one and two hours per session. All interviews were audio-recorded and transcribed within 24-36 hours of the conduct of each interview. In most organisations it was possible to subsequently contact and verify specific details generated during semi-structured interviews via telephone or a subsequent follow-up interview. In several cases multiple sessions were required to collect all the relevant data. In other cases additional participants were utilised to provide a full account of the phenomena, as detailed in Table 3-4. In all instances participants were provided with the opportunity to confirm and/or correct any issues associated with the initial data collection in a separate session outside the original interview.

The researcher also collected descriptive and reflective field notes during and after interview to provide contextual support for subsequent analysis. Field notes taken during interview were taken opportunistically and discretely so as not in unduly influence the conversation. The notes were taken using informal shorthand and subsequently rewritten into structured and more legible descriptions immediately following the interview.

Secondary data was also collected and collated from available organisational documents relating to the IT innovation. These documents where used to supplement and corroborate interview data. Secondary data was also used in the contextualisation and familiarisation processes forming part of the within cases analysis and the compilation of case vignettes (see Section 0).

Interview data was captured using digital audio equipment and the files subsequently stored securely with other data and records of the analysis.

3.4.4 Data Analysis

Data analysis was conducted in two stages. Stage one involved analysis of data from each individual case, organisational documents and field notes. Stage two involved a cross-case analysis, where data was reduced and consolidated in the context of different cases. The independent analysis of each case is important because it presents the IT innovation phenomena in different contexts. Thus within-case analysis is undertaken to maintain and minimise loss of context as data is reduced during cross-case analysis. Within case analysis also assists with the triangulation of analysis whilst investigating similarities and differences across cases (Stake 2013). Cross-case analysis allows themes and concepts to be evaluated and refined in different context (Darke, Shanks & Broadbent 1998), deepening understanding and explanation and addressing the transition of theory from the particular to universal (Miles & Huberman 1994).

This research accepts the view that data reduction, data displays and conclusion drawing are the essential overarching elements of qualitative data analysis (Miles & Huberman 1994), and that each element can involve a range of methods and techniques that the researcher must select to adequately address the objectives of the study.

This research makes extensive use of thematic analysis using the thematic the network analysis techniques described by Attride-Stirling (2001) and the step-by-step guidelines provided by Braun and Clarke (2006). The complementary techniques were used intensively for the within-case analysis reported in Chapter 4 and in conjunction with the cross case aggregation and display techniques advocated by Miles and Huberman (1994) in Chapter 5.

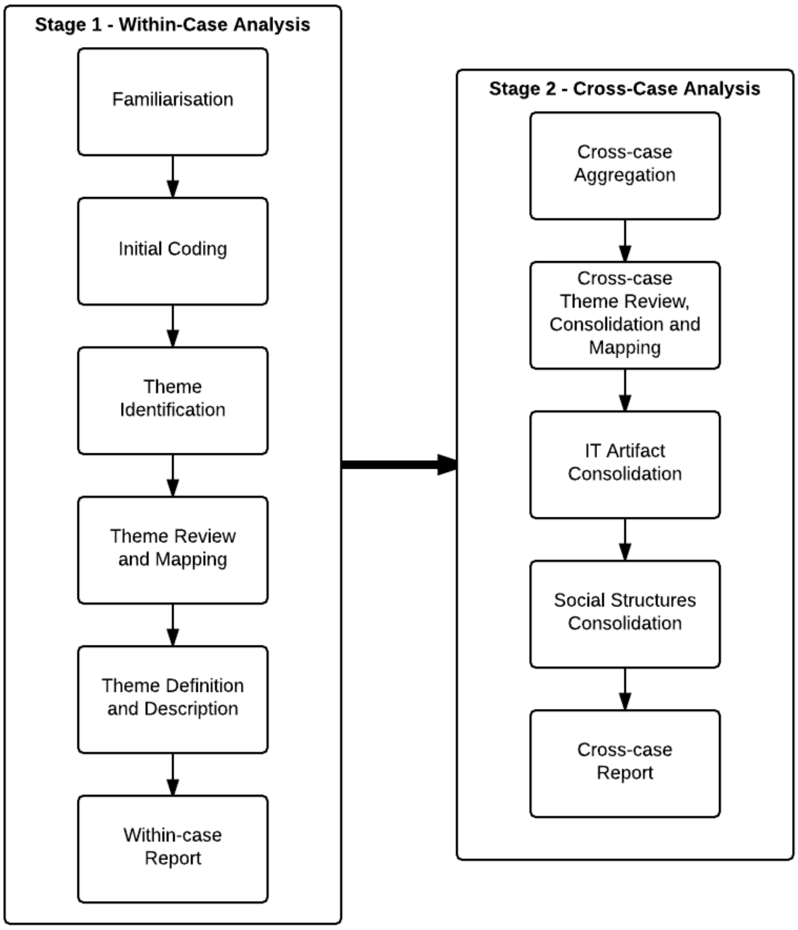
Thematic analysis can be undertaken on the basis of theoretical interests grounded in the research question or on salient issues grounded in the data (Attride-Stirling 2001). The latter is elsewhere described as the inductive approach to thematic analysis (Boyatzis 1998) and is the approach followed in this research.

Whilst fundamentally inductive, the inductive approach to thematic analysis it is still theoretically sensitive. According to Braun and Clarke (2006, p. 82) a theme represents both "a level of patterned response or meaning" grounded in the data set, and "something important about the data in relation to the research question". Naturally coding associated with this approach was also generated using inductive techniques that did not seek to fit the data into a pre-existing coding framework (Braun & Clarke 2006). Likewise themes were generated with increasing sensitivity to theoretical interests associated with this research.

During stage one, for each organisational case interview transcripts were coded and analysed using an inductive (data driven) thematic approach broadly based on the recommendations in Miles and Huberman (1994), but also utilising the detailed analytical techniques for thematic analysis described in Braun & Clarke (2006) and thematic networks described by Attride-Stirling (2001). Organisational documentation and field notes were also utilised to assist in providing context for each case and aiding understanding of the IT innovations investigated during interview.

During stage two, emergent themes from each case were reviewed, compared and contrasted in an iterative process using the analytical approach advocated by Miles and Huberman (1994). Similarities and differences across cases were identified and organised using meta-matrices structured around related themes, social structures and information technology artefacts to categorise the diversity of approaches and experiences in IT innovation practice.

Table 3-5. Overview of the data analysis process used in this research



The techniques and procedures used in this research are subsequently detailed in the following sections relating to the two stages of data analysis forming the basis for Chapters 4 and 5 respectively.

3.4.4.1 Within case analysis

Information systems research encompasses 'the effective design, delivery, use and impact of information technologies in organisations and society' (Avison & Elliot 2006, p. 3). In effect it explores behaviours and events associated with the interaction of information technology artefacts and social structures (Lee, AS 2001), an environment often referred to as being socio-technical. The role of socio-technical systems is also acknowledged within innovation theory (Geels 2004; Williams & Edge 1996).

Following Lee, AS (2001) and the socio-technical perspectives outlined in section 3.2, this research acknowledges the importance of the interplay of the social and the technical. It has employed an inductive thematic analysis process (Boyatzis 1998) utilising the guidance outlined in Braun & Clarke (2006), and the techniques for the display and description of thematic maps/networks advocated by Attride-Stirling (2001). This research also incorporated the additional activity associated with social structures and IT artefacts for use in analysis during the familiarisation phase.

Table 3-6. Extract of Braun & Clarke (2006) phases of thematic analysis.

Phase	Description of the process
1. Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Each case was analysed independently through the phases outlined by Braun & Clarke (2006) in Table 3-6 and encompassed the following activities:

FAMILIARISATION:

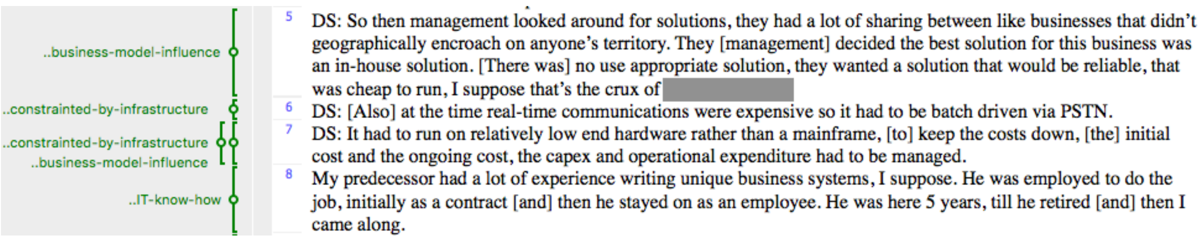
Initially the researcher reviewed the field notes and any secondary data that was collected in relation to the case. Interview data was then transcribed from the audio recordings. Memos were also taken during transcription to assist in the familiarisation process and to facilitate further analysis. At the completion of transcription, the researcher revisited the transcribed data, the memos, field notes and secondary data then summarised the case in a vignette (Miles & Huberman 1994). Next the transcription, field notes and any secondary data were then revisited again to identify and register the various social structures and IT artefacts associated with the case. The processes of transcription, reading and write-up of the vignette was consistent with the 'principle of contextualisation' (Klein & Myers 1999) and allowed the researcher to become 'familiar with the depth and breadth of the content' (Braun & Clarke 2006).

INITIAL CODING:

Interview transcriptions were then coded using the inductive open coding technique as recommended in Miles & Huberman (1994), originating in the work of (Strauss & Corbin 1990). Transcript data was coded at the sentence and paragraph level. Codes were developed from meanings interpreted within text, as opposed to using a starting set of codes based on prior theory.

Analytic memos were also added to reflect interpretation and to assist with the later phases of analysis. Computer software was used to facilitate the process and provide an efficient means of capturing and managing the code library. Figure 3-2 provides examples of the open coding process used in this study.

Figure 3-2. Illustration of open coding taken from an interview transcript in this study.



5 DS: So then management looked around for solutions, they had a lot of sharing between like businesses that didn't geographically encroach on anyone's territory. They [management] decided the best solution for this business was an in-house solution. [There was] no use appropriate solution, they wanted a solution that would be reliable, that was cheap to run, I suppose that's the crux of [redacted]

6 DS: [Also] at the time real-time communications were expensive so it had to be batch driven via PSTN.

7 DS: It had to run on relatively low end hardware rather than a mainframe, [to] keep the costs down, [the] initial cost and the ongoing cost, the capex and operational expenditure had to be managed.

8 My predecessor had a lot of experience writing unique business systems, I suppose. He was employed to do the job, initially as a contract [and] then he stayed on as an employee. He was here 5 years, till he retired [and] then I came along.

THEME IDENTIFICATION:

A theme is a pattern within the data that 'captures something important about the data in relation to the research question' (Braun & Clarke 2006, p. 82).

Attride-Stirling (2001) describes a network classification scheme for themes:

- Basic themes – first level themes derived from the textual data within coded text segments.

- Organizing Themes – a middle order theme that organises the basic themes into common concepts or meaning (clusters).
- Global Theme: Global Themes are super-ordinate themes that encompass the principal metaphors in the data as a whole.

The theme identification or selection phase is primarily concerned with abstracting basic themes from the open codes developed during the initial coding phase.

The open codes from the interview transcripts were reviewed where common and significant patterns and structures were extracted from coded text segments (Attride-Stirling 2001). The underlying patterns and structures that were interpreted as important to the research questions were then used as the basis for constructing basic themes.

THEME REVIEW AND MAPPING:

The basic themes developed in the previous phase were reviewed and grouped on the basis of related conceptual content. (Attride-Stirling 2001, p. 389) describes the process of review as the development of a thematic network:

'A thematic network is developed starting from the basic themes and working inwards toward a global theme. Once a collection of basic themes has been derived, they are then classified according to the underlying story they are telling and these become the organizing themes. Organizing themes are then reinterpreted in light of their basic themes, and are brought together to illustrate a single conclusion or super-ordinate theme that becomes the global theme'

This process was used to construct thematic network for the behaviours and events described in the interview transcripts in the context of the open codes. The emerging themes were then displayed using a graphical thematic mapping technique described by Attride-Stirling (2001) and similarly in Braun & Clarke (2006).

Global themes were sought to explain the case data as a whole. During the process of generating global themes the researcher was often left reflecting on the notion of each case representing some form or type of innovation. This notion was clearly a reflection of the researchers experience with prior theory. As a consequence this area of analysis required a level of sensitivity to be applied as to whether the theme was supported in the data or weighted more towards the theoretical preconceptions guiding the research design (Klein & Myers 1999). Through a process of revision and reflection the global themes were constructed in manner that the concepts appeared to be an appropriate fit in each case. As a consequence, global themes were mapped to IT enabled derivatives of product, process, marketing and organisational innovation more commonly seen within the innovation literature.

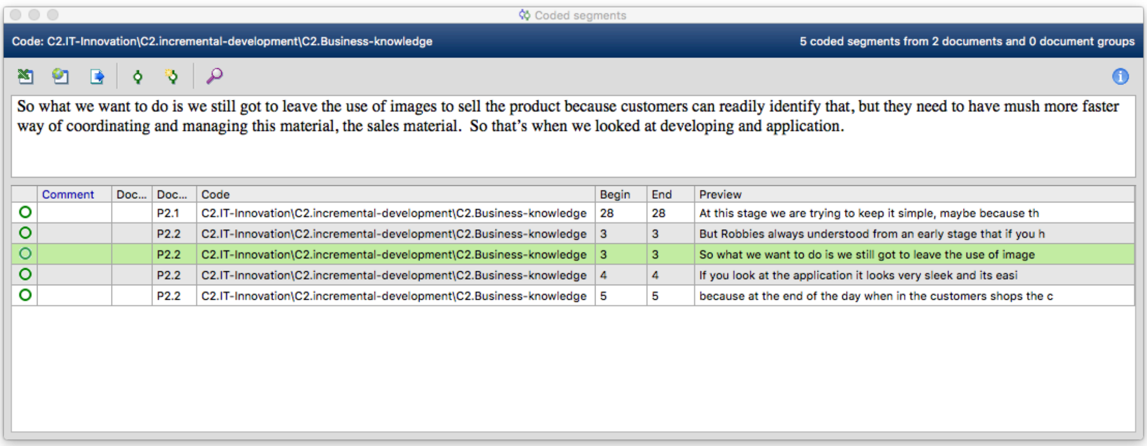
Attride-Stirling (2001) emphasise the role of the thematic network, describing it as a tool to be used by the researcher to conduct more detailed analysis and as a summary display to assist the user to understand the researchers interpretation of the data.

THEME DEFINITION AND DESCRIPTION:

Further analysis was required to describe and explore the network and present the patterns interpreted from the data. The thematic network developed in review phase was utilised to guide the researcher through further exploration of the text. Themes were defined and described in detail providing the researchers interpretation of themes and supporting that interpretation with text segments from the original transcripts (Attride-Stirling 2001; Braun & Clarke 2006).

Computer software was used to assist with the analysis, text within the themes were examined and incorporated into the analysis. Figure 3-3 provides an example.

Figure 3-3. Software facilitated analysis of text associated with themes



WITHIN-CASE REPORT:

One of the challenges of interpretive research is reporting the analysis in such a manner that it is convincing and able to be understood by the intended audience (Patton 1999). To address this challenge various elements of the analysis were integrated into the within-case report so as to describe the events, behaviours, IT artefacts and social structures of each case in their context.

Each case was reported independently and structured as follows:

- First, the case context was elaborated by presenting the case vignette along with a list of IT artefacts and social structures identified/developed during the familiarisation phase. The vignette was presented specifically to provide a thick description of the case in its context and to familiarise the reader with the case.
- Next, the emerging themes were presented using the finalised thematic network map developed in the theme identification and theme review and mapping phases; and
- Finally, the themes were defined and described in the context of the thematic map. Evidence to support the themes was provided in the form of embedded extracts from the data that were relevant to the theme and illustrated the interpretation of meaning.

3.4.4.2 Cross case analysis

The previous section described the first stage of analysis that looked at the data within each individual case. The within-case analysis focused on providing a thick description of the particular associated with each case. This section describes the second stage of analysis that was conducted to explore the themes, social structures and information technology artefacts across all cases. It was predominately concerned with deepening understanding and explanation in different contexts, and enabling the transition of theory development from the particular to the universal (Miles & Huberman 1994). Having cases purposely selected to maximise variation across cases also contributed to the utility of this process.

The cross-case analysis proceeded on the basis of guidance provided by Miles and Huberman (1994) where within-case data was partitioned in terms of the high-level research themes described in the heuristic model developed in Chapter 2.

Data analysis encompassed the following activities: (1) clustered cross-case aggregation, (2) cross-case theme review, consolidation and mapping, (3) consolidation of IT artefacts, (4) consolidation of social structures, and (5) a cross-case report.

CROSS-CASE AGGREGATION:

The emerging themes, IT artefacts and social structures identified in the within cases analysis were partitioned and aggregated in the context of the high-level research themes described in the heuristic model developed in Chapter 2 – (A) IT innovation decisions, (B) IT innovation activity, (C) IT innovation outcomes. The heuristic device was employed during this phase of the analysis to assist to focus the analysis on the high-level research themes and defend against information overload (Miles & Huberman 1994).

Within-case themes were aggregated using computer software that allowed the themes to be merged into a single code library, complete with links to inductive codes, transcript data, field notes and analytic memos. The within case-data was then reviewed identify any connection or relationship to the relevant research themes (partitions).

The aggregation of IT artefacts and social structures was conducted in a similar manner, however the case transcripts were reviewed in detail to determine the influence of each element within the partitioned research themes.

The aggregated themes, IT artefacts and social structures were then formatted and displayed in a partitioned case ordered 'meta-matrix' (Miles & Huberman 1994). An extract of the meta-matrix is provided in figure 3-4. The extract illustrates the first few rows associated with the partition for IT innovation decisions.

Figure 3-4. Extract of partitioned case ordered meta-matrix used for aggregation.

Research Theme 1: IT Innovation Decision

Case	Case Memos	Themes	Social Structures	IT Artefacts
1	Organisation 1 was Unable to find a suitable POS solution at an affordable price. Management ultimately decided to develop software in-house to meet their requirement. Decisions to take this direction were influenced by the organisations low cost business model as more expensive solutions were available at the time. Following the initial innovation, software platforms and infrastructure were changing rapidly and new platforms had become available making the initial platforms near obsolete. Further decisions were made to redevelop software to mitigate various platform and equipment dependencies. Additional functionality was added in response to business requirements. Part of the development of this functionality was temporality outsourced to an external software developer.	<u>Solution-selection-problem</u> Imperfect-existing-solutions+ Business-model-influence Constrained-by-infrastructure-costs. <u>Incremental development</u> (Decision-in-phases+) Continuous improvement Long term evolution <u>IT platform changes</u> IT market innovation IT dependencies Requirements-from-testing	Organisation management In-house IT developers	Retail software POS Equipment Database Management Systems Software Development Environment Communication utility Wide Area Network System architecture
2	Innovation in Case 2 was initiated by the management of Organisation 2a when they recognised that there were a number of problems with the existing sales process. Sales staff utilised a basic layout and design (BLAD) style catalogue to facilitate sales with customers in conjunction with PDA barcode readers to capture the orders. Maintenance of the BLAD style catalogues incurred significant overheads and they were bulky for the sales staff to transport and use in the sales environment. However the BLAD catalogues were seen as an important marketing and sales facilitation tool by sales staff and management.	<u>Solve-a-business-problem+</u> Information-handling-problem+ Unhappy-with-existing-system+ <u>Incremental-development approach</u> Phased development (Decision-in-phases+)	Organisation 2a business owners Organisation 2b software developers Organisation 2a sales staff	Organisation 2a's ERP platform Sales Order PDAs+

CROSS-CASE THEME REVIEW, CONSOLIDATION AND MAPPING:

Using themes from the partitioned case ordered meta-matrix as a guide, a new phase of thematic analysis was conducted from a cross case perspective. Global themes were established around the high-level research themes (the meta-matrix partitions). Existing themes were then extracted from the case ordered meta-matrix and reviewed in context of the underlying codes, field notes and memos. New consolidated and clustered-organising themes were then generated from the existing data across cases. These new themes represented a broader level or scope of reduction than the basic and organising themes generated during the within-case analysis. The terms consolidated and clustered-organising are used respectively to distinguish the difference in analytical scope. This terminology is consistent with tactics described in Miles and Huberman (1994).

A thematic network map was also generated and utilised as per the within-case analysis in section 0.

During the review and reduction of data, computer software allowed the researcher to move back a forth through thematically coded text segments from the interview transcripts to ensure the relevance and appropriateness any new themes, acknowledging that relationships can be formed by both similarities and differences (Stake 2013).

The consolidated and clustered-organising themes were then defined and described. The definitions and descriptions of consolidated themes were also supported with links to instances of basic or organising themes from specific cases.

CONSOLIDATION OF IT ARTEFACTS:

The IT artefacts identified within cases were re-examined to consolidate and identify classes of information technology that were present and influential in each of the high-level research themes (partitions). The codes used to identify IT artefacts were consolidated in a case ordered display and classified into high-level archetypes (see figure 3-5).

The terminology used to classify IT artefacts was influenced by the researchers knowledge and experience of the IT industry and common classification schemes applied to information technologies from within the literature.

Each class of IT artefact was defined and described in the context of themes and instances found in specific cases.

Figure 3-5. Extract of case ordered display used for classification and consolidation of IT artefacts.

Case	IT Artefact	Clustered Archetype	Code
1	Retail software	Application	C1.Retail software
1	Communication utility	Application	C1.Communication utility
1	POS Equipment	Application	C1.POS Equipment
2	Mobile sales ordering software	Application	C2.Mobile sales ordering software
3	Aquaculture production control software	Application	C3.Aquaculture production control software
3	Microsoft Excel	Application	C3.Microsoft Excel
4	Existing property management systems	Application	C4.Existing property management systems
6	Medication management software	Application	C6.Medication management software
6	Prototype software	Application	C6.Prototype software
7	Mobile applications	Application	C7.Mobile applications
8	Virtual printer software	Application	C8.Virtual printer software
8	Email	Application	C8.Email

CONSOLIDATION OF SOCIAL STRUCTURES:

Using a process an almost identical to that used for consolidating the IT artefacts, the roles and actors (social structures) identified within cases and influential for each of the high-level research themes (partitions) were re-examined, grouped and classified into high-level archetypes (see figure 3-6).

The terminology used to describe the archetypes was influenced by researcher experience and common terminology pertaining to the classification of actors and agents found within business and IT literature.

Each social structure archetype was defined and described in the context of themes and instances found in specific cases.

Figure 3-6. Extract of worksheet used for consolidation of social structures.

Case	Social Structure	Clustered Archetype	Code
1	Store managers	Customer/User	C1.Store managers
1	Users	Customer/User	C1.Users
2	Organisation 2a sales staff	Customer/User	C2.Organisation 2a sales staff
2	Organisation 2a's customers	Customer/User	C2.Organisation 2a's customers
3	Operational staff	Customer/User	C3.Operational staff
4	Marketing department	Customer/User	C4.Marketing department
4	Internal business customers (users)	Customer/User	C4.Internal business customers (users)
5	Resource management specialists	Customer/User	C5.Resource management specialists
5	Operational staff	Customer/User	C5.Operational staff
6	Hospital clinical pharmacy practices	Customer/User	C6.Hospital clinical pharmacy practices
6	Clinical pharmacists	Customer/User	C6.Clinical pharmacists
7	Remote indigenous populations	Customer/User	C7.Remote indigenous populations
8	Organisation 8b customers	Customer/User	C8.Organisation 8b customers
8	BPO organisation	Customer/User	C8.BPO organisation
9	Users	Customer/User	C9.Users

CROSS-CASE REPORT:

The final phase of the cross-case analysis was not unlike the within-case approach and sought to bring together the analysis using a format that was convincing and able to be understood by the intended audience (Patton 1999).

Each of the high-level research themes was reported separately.

Initially emerging themes were presented in terms of a truncated case-ordered display extracted from the meta-matrix generated during cross case aggregation. Consolidated and clustered-organising themes were then presented in the form of a thematic network map and then narrative definitions and descriptions generated during the cross-case theme review, consolidation and mapping phase. Social structures and IT artefacts were reported in a similar manner, with the exception of the truncated case order display, which the researcher felt would be implicit to the reader when reviewing the definition and descriptive accounts.

3.4.5 Discussion and Interpretation

This section provides an outline of the approach taken in Chapter 6 to discuss and interpret the results from the within-case and cross-case analysis.

Interpretation and discussion progressed in three phases:

(1) First, the findings from the case data and analysis were revisited and interpreted to produce an empirically grounded model of IT innovation for the nine case studies of IT innovation practice.
(2) The empirically grounded model was then discussed in the context of existing literature and its relevance to IT innovation theory and practice.
(3) Then, based on this discussion a knowledge framework was generated to extend previous theory associated with IT innovation and implementation, integrating insights from contemporary innovation theory grounded in the multi-case analysis and findings.

The within-case analysis provided an in-depth understanding of IT innovation within specific context, revealing factors that were influential and relevant to the specific case. The cross-case analyses provided a method to review and interpret patterns that exist among the emergent themes and inter-relationships within and between cases. The utility of this analysis is well supported in the literature, as understanding innovation inevitably involves drilling down into the domain to examine the common patterns and cases (Rosenberg 1994).

The first phase assisted in answering the first research question – how and why do firms innovate with IT?

The second and third phases assisted to answer the second research question – how can organisational approaches and experiences in IT innovation be analysed?

3.5 Evaluating the quality and credibility of this research

Section 3.3.2.6 outlines the quality and credibility challenges associated with this research. This research has drawn upon the guidance provided by Klein and Myers (1999) to address many of the limitations associated with the qualitative-interpretive approach.

Table 3-7 The application of Klein and Myers (1999) seven principles in this research.

Principle	How it was applied in this study
1. Principle of Hermeneutic Circle	The hermeneutic process was applied to data collection and analysis. Data was collected via interviews and transcribed into text. An inductive (data driven) thematic approach was utilised in the initial analysis, drawing themes from inductive codes that were analysed on a line-by-line basis. The analytical process was iterative moving back and forth through various levels of the thematic process as advocated by Braun & Clarke (2006) and Attride-Stirling (2001). The second stage, emergent themes from each case were reviewed, compared and contrasted in an iterative process using the analytical approach advocated by Miles & Huberman (1994).
2. Principle of Contextualisation	This research employed a case study approach, which in itself is a research strategy that investigates a phenomenon within a real-life context (Yin 2013). For each case a vignette was presented specifically to provide a thick description of the case in its context and to familiarise the reader with the case. Context was further elaborated by presenting a list of IT artefacts and social structures identified/developed during the familiarisation phase.
3. Principle of Interaction Between the Research and Subjects	The primary data collection method used in this research was the semi-structured interview. The semi-structured approach provides flexibility and constraint of the participant, keeping interactions focused whilst allowing for individual perspectives to emerge. The interview guide along with the procedures employed for this research is described in section 3.4.3. The researcher recorded and transcribed interviews, took field notes during and after interviews, used probes to encourage participants to elaborate on their answers, avoided leading questions, and collected secondary data to support the interviews. Interaction between researcher and participants in this research was extensively in the role of an outside observer maintaining distance from the participants and not directly participating or influencing the context or interact with the phenomena (Walsham 1995).
4. Principle of Abstraction and Generalisation	This research utilises an inductive theory building approach that takes detailed observations and uses them to generate theory, then linking theory to abstract ideas (Patton 2002). Under the inductive theory building approach the researcher attempts to extract meaning from the experiences of participants in order to describe and explain phenomena (Creswell 2013). Generalisation in this research takes the form of transferability, where the reader is provided with a detailed breakdown of the research process and a thick description of the cases and analysis in order to facilitate interpretation and judgment of its transferability into other contexts.
5. Principle of Dialogical Reasoning	This research adopted a subjective ontology and interpretive epistemology, this research philosophy is explicitly declared through various sections of this thesis, the methods and techniques employed by this study are also justified in same context. Prior theory was reviewed towards the end of this study, during the analysis and interpretation phases to provide sensitivity to any contradictions between the findings of this research and theory found within literature.

Principle	How it was applied in this study
6. Principle of Multiple Interpretations	This research employed a multi-case design to provide different perspectives of IT innovation phenomena. For each case multiple sources of data were collected to verify or elaborate participant stories, where available multiple participants were interviewed for the same case. The rules and guidelines set by the research institution overseeing this doctoral research project limited the possibility of utilising multiple researchers to conduct case studies and thus provide multiple researcher interpretations.
7. The Principle of Suspicion	Klein and Myers (1999) leave it open for researchers to choose not to follow this principle in their work. This research embraces the process of reconciling contradictory or paradoxical evidence from cases (Eisenhardt 1989a) and seeks to minimize researcher-influenced bias by utilising multiple sources of evidence. The critical component of this principle advocated in Klein and Myers (1999) is in many ways inconsistent with the interpretative epistemology adopted for this research and addressed only to the extent outlined above.

3.6 Ethical considerations

Ethics define how the researcher acts with respect to the collection, analysis and reporting of research data. It is particularly important when dealing with human participants and behaviours in complex open systems.

This research adopted a utilitarian approach to ethics that focused on informed consent, the avoidance of harm and the maintenance of confidentiality (Flinders 1992).

Participants were recruited into this research voluntarily, with informed consent. Participants were provided with an information sheet that outlined the purpose of the research, why they were being considered, what was involved, the benefits of participating and the risks associated with their participation. An example of the information sheet used in this study is provided in Appendix A.

Immediately prior to the commencement of data collection participants were asked if they understood the information sheet along with the nature and possible effects of the research. It was clarified that they understood that the research involved the collection of data via recorded interviews and that transcripts of those interviews would be made for the purpose of analysis and reporting. The researcher then confirmed that the participant was aware of the procedures that were to be used to protect their privacy and confidentiality during the research process. Finally it was emphasised for the participant that their participation was voluntary and that even though they may have agreed to participate that they could, at any time withdraw and have any data withdrawn at their request. An example of the consent form used in this study is provided in Appendix B.

Overall it was the intent of the researcher to protect the participant from any disclosure of information and identity that might result in ‘stress, embarrassment or unwanted publicity resulting from the publication of research findings’ (Flinders 1992).

The data and information collected in the research was only collected for the purposes of the research. All data (audio tapes, transcripts, field notes) were kept securely during the research process, with the data to be stored and retained secure conditions at the University of Tasmania for a period of at least 5 years after completion of the research.

This research obtained approval from Tasmanian Health and Medical Human Research Ethics Committee, reference number H9949.

3.7 Chapter summary

This chapter presents the research design and methods used to conduct this research. It outlines the research philosophy adopted by this research, describing the selection and justification of a subjective ontology in combination with an interpretive epistemology as being both appropriate to answer the research questions, and accepted within the domains of information systems research and management science.

This chapter also describes the research strategy and the procedures used to select cases, collect and analyse data.

A multi-case study method was employed in conjunction with a qualitative design to explore nine cases of IT innovation in an organisational context. Cases were purposefully selected from organisations involved in the development, implementation and/or use of IT with the objective of achieving maximum variation amongst cases. This variation was achieved by selecting cases of different innovation types; areas of application; and organisational context, including organisations of different size, geographical scope and primary business activity. Selected cases included organisations from both the IT producer and IT user sectors.

Data collection involved the use of face-to-face semi-structured interviews, documents and field notes. A semi-structured approach was favoured in order to focus conversation on high level issues associated with IT innovation and to assist to avoid constraining participant responses to issues derived from prior theory. Interviews were conducted with stakeholders who were directly involved with IT innovation specific to a case study. Interviews were guided by an interview protocol derived from the theoretical framework described in Chapter 2. The interview was protocol designed to generate insight into the antecedents, behaviours and consequences of IT innovation.

At a general level, the data analysis process followed the regime of data reduction, data display and conclusion drawing advocated by Miles and Huberman (1994). It was also acknowledged that research associated with innovation and information technology systems was being undertaken within a socio-technical environment, and the scope of data analysis should incorporate the analysis of behaviours and events associated with the interaction of information technology artefacts and social structures (Lee, AS 2001).

The analysis itself was conducted in two stages. Stage one involved analysis of data from individual cases. Stage two involved a cross-case analysis, where data was reduced and consolidated in the context of different cases. Where the within-case analysis focused on providing a thick description of the particular associated with each case, the cross case analysis was concerned with deepening understanding and explanation in different contexts, and enabling the transition of theory development from the particular to the universal.

Within-case data analysis followed the detailed guidance for inductive thematic analysis provided by Braun & Clarke (2006) and Attride-Stirling (2001) and transitioned through six activity phases – familiarisation; initial coding; theme identification; theme review and mapping; theme definition and description; and within-case reporting.

The cross-case analysis proceeded on the basis of guidance provided by Miles and Huberman (1994) where within-case data was partitioned in terms of the high-level research themes described in Chapter 2. Data analysis transitioned through five activity phases – clustered cross-case aggregation; cross-case theme review, consolidation and mapping; consolidation of IT artefacts; consolidation of social structures; and cross-case reporting.

At the conclusion of data analysis various techniques were employed to interpret and discuss the analysis. The results of the within-case and cross-case analysis were interpreted to produce an empirically grounded model of IT innovation for the case studies. Findings from case studies were then contrasted with the existing literature and used to develop an improved knowledge framework for future IT innovation research.

The investigator undertook to maintain the credibility and quality of this interpretive research by incorporating and reflecting upon the guidance provided by Klein and Myers (1999) throughout the study. The selection of research methods and design were influenced by principle of the hermeneutic circle and the discovery of meaning through the interpretation text.

Finally this chapter outlines the ethical considerations undertaken as part of this research. A utilitarian approach was adopted focusing on informed consent, the avoidance of harm and the maintenance of confidentiality.

The next chapter presents the analysis of the data for within each of the nine cases of IT innovation practice using an inductive (data driven) approach complemented by thematic analysis techniques.

4 DATA ANALYSIS PART 1 – WITHIN CASE ANALYSIS

4.1 Introduction

This chapter provides the results of the first of two phases data analysis, reviewing the themes, social structures and information technology artefacts emerging within each of the nine cases studies of information technology innovation.

- Section 4.2 through to section 4.10 provides a detailed independent analysis of each case. Each section provides a vignette outlining the context of each the cases study followed by a description of the themes, social structures and information technology artefacts that emerged from interview transcripts and field notes. Themes were summarised and discussed in the context of a thematic map that was derived from an inductive code process as outlined in the research methodology in Chapter 3.
- Section 4.11 provides a summary of the analysis and introduces the next phase of cross case data analysis.

Each case that forms part of this study is part of collection of cases concerned with innovation involving the use and/or development information technology. Each case is important in its own right because it presents the innovation phenomena in different contexts. Independent analysis of each case (the within case analysis) is undertaken because it assists to maintain and minimise loss of context as data is reduced during later stages of analysis. Within case analysis also assists with the triangulation of analysis whilst investigating similarities and differences across cases (Stake 2013).

Nine cases were purposefully selected from organisations involved with the development, implementation, and/or use of IT with the objective of achieving maximum variation (Patton 2002). Cases were also stratified in terms of being classified as belonging to the IT producing sector or IT user sector. Five cases were selected from the IT user sector and four from the IT producing sector see Section 3.4.2 for a profile of the selected cases.

4.2 Case 1 – Retail software development

4.2.1 Context

4.2.1.1 Innovation activity and events

Case 1 investigates information technology innovation in relation to a discount variety business (Organisation 1) operating in the retail sector in Tasmania, Victoria and South Australia. The case follows two long-term information systems development initiatives that had progressed from 1996 through to 2009. It primarily focuses on the innovation activity associated with the redevelopment of a point of sales/inventory management system and a staff time and attendance/rostering system. Both systems were implicitly linked to the organisations retail strategy but followed subtly different sourcing approaches.

Two separate interviews were conducted with the information technology manager who oversaw a great majority of both developments.

Organisation 1 had previous developed its own point of sales and inventory management system. At the time of development the business was unable to find a solution that was reliable and low cost. The business was particularly concerned with, and burdened by, poor communications options at the time. It felt that it could not depend upon many of the solutions that were networked and utilised a centralised server based processing model.

The business engaged an experienced professional to develop the software. This person was subsequently hired as an employee to progress the development over a five-year period. During the period of development and the sequent deployment of the first version, a number of platforms and technologies for which the system had become depend upon progressed through considerable change. Eventually the system required a major overhaul to allow new functionality and ongoing support for new technologies and platforms.

The system overhaul involved a complete redevelopment of the software systems and the deployment of new operating platforms to support it. Development progressed using in-house information technology staff. Information technology staff consulted closely with the end-users and management around the requirements. The development team focused on delivering basic functionality around point of sale, stock control and financial control. Over time the system was enhanced to provide broader functionality such as central warehousing, budgeting, petty cash and customer loyalty. The development team made explicit use of live prototyping methods during development.

Beyond software development significant work was also extended towards the design of a resilient systems architecture that allowed the software to operate in a standalone mode and not be reliant on real-time communications to process transactions or provide operations.

Similarly Organisation 1 had also progressed the in-house development of a staff rostering and scheduling system. This system had limited functionality and lacked features to support changes in the way the business was now managing it stores through area managers. Labour in conjunction with stock and rent was one of the businesses major expenses and it sought to optimise and manage it effectively. Having staff rostered and available for each store was important for operations.

At the time when the organisation needed to add new functionality to the rostering and scheduling system, internal information technology staff were predominately committed to progressing enhancements to the point of sales system. As a consequence, Organisation 1 decided to seek external assistance to redevelop the rostering and scheduling system. As with the point of sale system, dependent platforms and technology had progressed to a point that it dictated a complete redevelopment of the software along with the introduction of new database platforms and software development frameworks.

Again the development approach involved close consultation with users and managers, but the organisation found that the additional layer of documentation and scoping in combination with users adding to the scope caused the project to overrun its budget by about a third. Considerable differences where encountered in what the users and managers had agreed in the requirements to what they were prepared to accept in terms of developed functionality.

Eventually the development was moved back in-house. Satisfaction with the external development team was high from a technical perspective, but the organisation found that problems articulating requirements in a strictly documented form was causing issues with internal acceptance and ultimately the quality of the developed outputs.

As development progressed in-house with the rostering and scheduling system, functionality was stabilised and the system developed to a point where it aligned well with the usability requirements of the end-users.

Organisation 1 was considered to be a very successful business within the highly competitive discount variety sector. Its low-cost business model, and focused product price and positioning strategy, appeared to have successfully disrupted the major discount variety chains in the markets that it competed. The information technology innovation associated with both systems appears to have provided a significant contribution to the organisations' success. Both systems were by relative standards low cost and closely aligned to the needs of business users. Organisation 1 was acquired by another business in 2009 on the basis of its success. However the acquiring business was subsequently placed into insolvency in 2012. As a consequence Organisation 1 is no longer trading.

4.2.1.2 Social structures

Innovation activity in Case 1 was predominately undertaken with internal actors, with the exception of some software development work on the scheduling module that was undertaken with in an external software development organisation.

Table 4-1. Summary of actors and their roles in innovation in Case 1.

Actor	**Description and role**
Organisation 1	Discount variety retailer and setting for innovation in Case 1.
In-house IT developers	Specialist IT staff that took in multiple roles – software development, system architecture, network deployment along with the requirements gathering and facilitation of testing with users.
External software developers	Third party software development specialists focused on software development from specifications provided by in-house IT developers.
Store managers	Managers of the retail outlets, provided business requirements and feedback to in-house IT developers on software suitability/fitness for purpose.
Users	Users of the system/software, provided business requirements and feedback to in-house IT developers on software suitability/fitness for purpose.
Organisation management	Provided high level business objectives for the innovation and approvals around the approach and budget.

4.2.1.3 Information technology artefacts

Innovation in Case 1 primarily involved the development of retail software, however there were a number of complementary information technology artefacts connected with the innovation. Table 4-2 summarises the information technology artefacts involved.

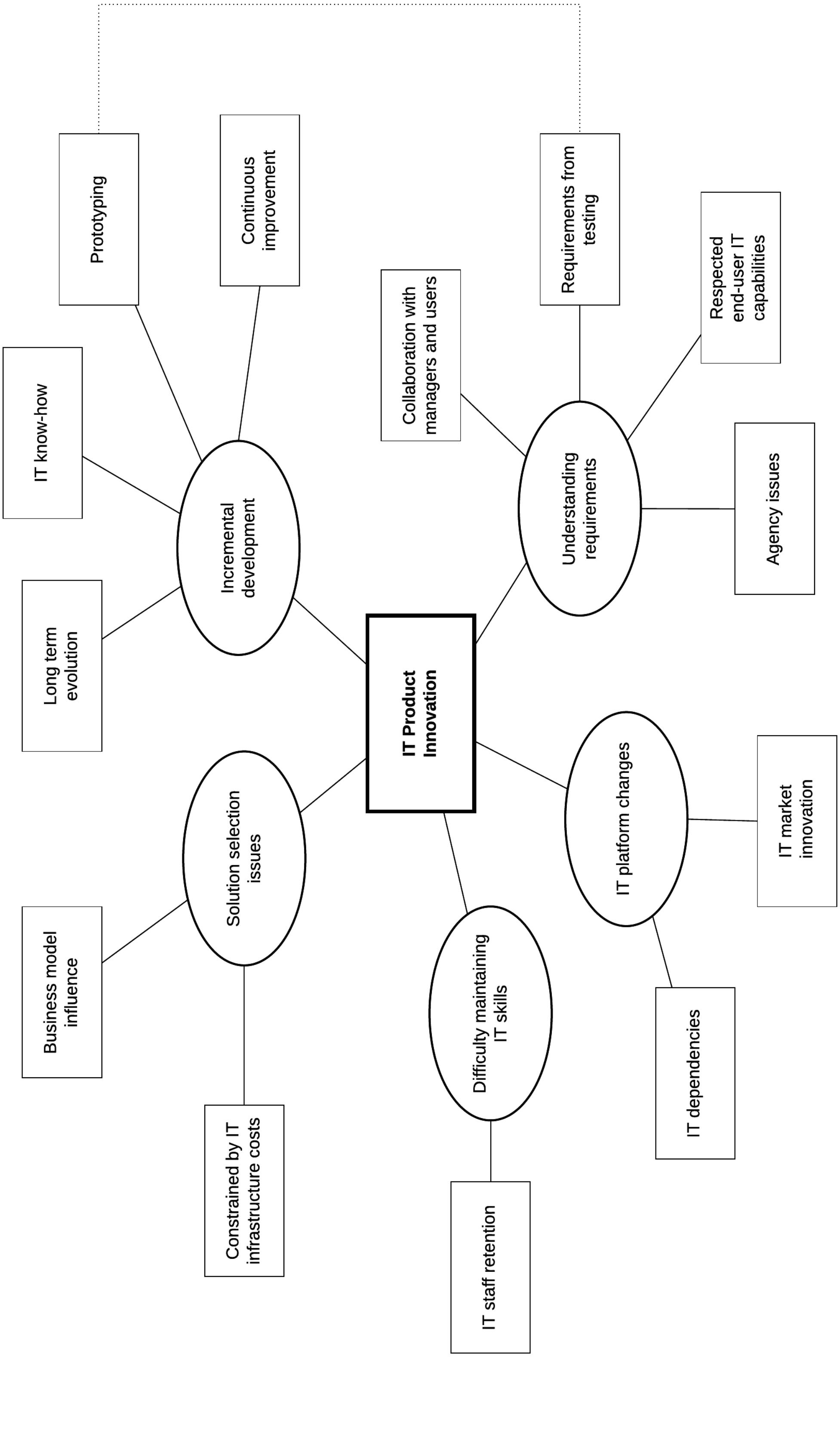
Table 4-2. Summary of information technology artefacts involved with Case 1.

Artefact	Description
Retail software	The primary artefact was custom written software developed via a combination of in-house and external effort.
Database Management Systems	Different database management systems (DBMS) were employed through the lifecycle of the system – FoxPro then MS SQL.
Software Development Environment	Different integrated software development environments employed through the lifecycle of the system. Initially FoxPro, then Visual FoxPro then MS Visual Studio.
Communication utility	A communications utility was utilised in the earlier stages of development where network communications and file transfer protocols were limited.
POS Equipment	Point of sale equipment – computers, printers, and scanners was deployed to operate the software.
Wide Area Network	A wide area network was established to communicate with sites.
System architecture	The combinational design or assembly of software, equipment and networks that allowed the systems to function as a whole.

4.2.2 Emerging themes

Following a sequence of inductive coding and analysis, fourteen themes emerged for Case 1 and were arranged into five groups of related content associated with the single global theme of information technology product innovation. Figure 4-1 illustrates the thematic network for Case 1.

Figure 4-1. Case 1 Thematic network



The global theme of *information technology product innovation* pertains to the development and successful use of a novel information technology solution within the organisation. The themes and their groupings in the network are summarised in table 4-3 below.

Table 4-3. Case 1 emerging themes

Organising Theme	**Theme**	**Definition**
Solution selection issues	Business model influence	The organisation's business model influenced decisions about the suitability of solutions
	Constrained by infrastructure costs.	The solution choices available to the organisation were constrained by the costs of communications and IT services infrastructure.
Incremental development	Continuous improvement	An iterative process was employed to refine the design and output of innovation activities.
	Long term evolution	Functionality of solutions increased and improved over a long time period.
	Prototyping	Designs were implemented and tested in operational scenarios.
	IT know-how	The knowledge required to progress IT development.
Understanding requirements	Collaboration with managers and users.	Interaction with business managers and users to determine the requirements.
	Requirements from testing	Developing requirements from testing (linked to prototyping)
	Respected end-user IT capabilities	Took the capabilities and skills of end-user operators into consideration when designing solutions and new functionality.
	Agency issues	Problems articulating business requirements with externally sourced development teams.
IT platform changes	IT market innovation	Innovations originating in the general IT marketplace pertaining predominately to IT platforms.
	IT dependencies	The reliance of modules, components, applications upon changes to IT platforms.
Difficulty maintaining IT skills	IT staff retention	Problems retaining internal staff and the associated IT skills and capabilities.

4.2.2.1 Solution Selection Issues

Organisation 1 was pursuing a single market, focused low cost business model. The organisations vision, behaviour and branding reflected this business model. When it came to information technology investments a lean approach was typically taken, and this appears to have influenced a great deal of solution selection and information technology decision-making.

P1: “They [management] decided the best solution for this business was an in-house solution. [There was] no use appropriate solution, they wanted a solution that would be reliable, that was cheap to run, I suppose that’s the crux of [Organisation 1]...”

As a consequence complementary or co-dependent infrastructure investments were also constrained by their relative cost. Although it is important to reflect on the time (era) that some of these investment were being made. For example broadband communications had only started to become available in the areas where Organisation 1 was operating. The cost to establish and operate a broadband network was relatively high. Similarly client-server retail point of sales and inventory systems were fairly rare, main-frame systems tended to dominate and be highly expensive.

P1: “ … at the time real-time communications were expensive so it had to be batch driven via PSTN. It had to run on relatively low end hardware rather than a mainframe, [to] keep the costs down, [the] initial cost and the ongoing cost, the capex and operational expenditure had to be managed.”

The combination of solution availability, costs and the low cost business model appears to have had a major influence on the sourcing strategy undertaken by Organisation 1.

4.2.2.2 Incremental development

Both systems were developed on a continuous improvement basis, adding functionality and fixing issues over a long time period. With the period of evolution spanning approximately 14 years.

P1: “Things were added down the track like petty cash functionality, budgeting for sales, We set weekly budgets for shops, the shops have the ability to break that down by day, so that would have came later. Things like inter-store transfers, all the stock at the time was driven from the central warehouse to the shops. Something like stock transfers would have been needed so we added that functionality in.”

The use of a formal methodology was not declared during the interviews, however it was apparent that the development of both systems was undertaken using an incremental approach. Prototyping methods were employed to allow the users to test new functions and concepts and further refine software requirements.

P1: “The initial system that went in gave us some basic functionality, stock control functionality and financial control [and] then it was enhanced. I’d say it was originally prototyped live then enhanced.”

Organisation 1 initiated development by sourcing the information technology knowledge to develop a system in-house. As time progressed Organisation 1 added resources to progress the ongoing development of the point of sales system.

P1: "My predecessor had a lot of experience writing unique business systems, I suppose. He was employed to do the job, initially as a contract [and] then he stayed on as an employee. He was here 5 years; till he retired [and] then I came along."

When the decision came to progress with improvements to the staff time and attendance/rostering system Organisation 1 sourced information technology development knowledge from an external development team. The external team appears to have taken a more formalised approach to development with emphasis on scope and cost (see agency issues in section 4.2.2.3).

4.2.2.3 Understanding requirements

Considerable emphasis was placed on collaboration with managers and users to establish the system requirements.

P1: "[The development] was a full in-house development with consulting with end-users and management about what they actually wanted."

The users and managers drove most of the functional design, but there were a range of functions introduced from the IT team on the basis of perceived need, possibly gained from their relationship users and the embedded nature the information technology function within the business.

Requirements appear to have been better understood at testing as opposed to requirements gathering sessions. Interview transcripts emphasise the role and importance of user tests in understanding requirements.

P1: "I suppose what has been the interesting side of all this is what we put on paper and what we developed, is that the users are very good at knowing, [or should I say] not knowing what they do want but knowing what they don't want when they see it. They find things that aren't right or are missing … we needed to do this or we needed to do that or you didn't mention that, or we don't like this because it doesn't tab the right way."

The in-house development team also demonstrated a high degree of sympathy and respect for the information technology skills and capabilities of the end-users. This acknowledgement appears to have translated in to successful deployment.

P1: "It's very easy to use, because our staff are not very computer savvy, they are not experts in using computers. I know with Internet access and home computers it has changed a little bit, but never the less it's simple to use, its logical and even with our recent rollout into Victoria, we took out all the existing systems and put our systems in, they picked it up really quickly.

There was however issues understanding requirements when the organisation started to utilise external development resources. It appears that issues emerged in scoping and costing of requirements.

P1: "… you had to get a quote, scope out, tick off all the wish list things in there along with the mandatory things, work out how much we could spend and prioritise everything and say do this, this, this and forget about that because it's too much and yea will do this wish list thing because it's only an extra 50, because you're doing everything else. That was always a concern."

The basis of this problem is the need for mechanisms to be put in place by either Organisation 1 or the external provider to mitigate risk in the work packages. Thus a need to scope what was required and agree in writing and on cost before proceeding. This issue coupled with general problem of articulating the requirements for functional design caused budget and time overruns. Furthermore, the issue also initiated trade-offs in priorities based on development price rather than business priority, a dimension of change that had not previously influenced design decisions.

4.2.2.4 IT platform changes

Organisation 1 undertook its information technology innovation activity over a long period of time and initially during a period of extensive innovation within the information technology marketplace itself. As a consequence, the platforms that underpinned the original information technology development at Organisation 1 had been replaced by new platform innovations. These changes had a significant influence on how development proceeded and subsequently evolved moving forward.

P1: "Fox Pro 2.6 was fairly strong back in 1996, it was very popular."

"By the time I came along it [the system] was a bit tired and we had to do an upgrade. We had to rewrite the system so we took it to Visual Fox Pro 9 [VFP], which was the last release of from Microsoft. Now they all run Windows XP on the POS and Windows Server 2003 on the back office. That's where we are at the moment."

P1: "We got them to spec up and develop a system for us, using more modern technologies, hence .Net and SQL. .Net C#."

Through the lifecycle Organisation 1 transitioned its database and development platform from a non-relational database and procedural based programming architecture through to relational database management and an object oriented programming architecture.

There was also a range information technology dependencies linked into the process of change and improvement. Changes with various dependences were cited as barriers to development.

P1: "think the barriers which presented themselves further down the track were the 3rd party products that were relied upon. One of them which comes to mind was a comms product called Reachout. Reachout had a scripting language in it. What our system did is produce zip files to go to the shop sand to come back from the shops. We had a system which automated this script and fired off Reachout. It basically pushed out the files and deleted them when they need to be etc."

"Reachout was discontinued about 1998, I think it was acquired by another company for its compression algorithm, they didn't want the remote control software. To date I have not seen a product as efficient …"

4.2.2.5 Difficulty maintaining IT skills

Access to information technology development knowledge and the ability to apply that knowledge was an important component of Organisation 1's success with information technology innovation. Interview transcripts highlight problems Organisation 1 had developing and maintaining skills and retaining internal staff.

P1: "Staff [IT] retention I suppose is our biggest threat. I think its salary and prestige. We can attract Uni graduates pretty well but I think down the track when they get a bit of skill behind them there is a bigger carrot dangling. They are happy to make a start, be here a couple of years then they can see themselves as a system architect in ten years time and I'm not going to do that here. So career progression I suppose is limited."

4.3 Case 2 – Mobile sales ordering system

4.3.1 Context

4.3.1.1 Innovation activity and events

Case 2 investigates information technology innovation associated with the development of a mobile sales order entry system for a wholesale business distributing confectionary and snack foods to independent retailers in the Tasmanian marketplace (Organisation 2a). The innovation is characterised by a collaborative relationship with another business from the information and communications technology (ICT) sector that specialises in software development (Organisation 2b).

Two interviews were conducted – one with an employee from organisation 2a, who essentially performed the role of a business analyst and was embedded in the day to day processes of Organisation 2a; and another with the head of the development team from Organisation 2b, who managed the development process and relationship with Organisation 2a.

Organisation 2a is small business with approximately 20 employees. The business services a diverse group of retailers that are categorised as independent retailers. This group of retailers would typically include – takeaway stores, petrol & convenience stores, independent supermarkets, pharmacies, newsagents, video stores, bottle shops and hotels, school canteens, sports clubs, licensed clubs, restaurants, cafe and coffee shops. Organisation 2a's business model is primarily one of warehousing and distribution, where a wholesale volume of goods are procured from branded manufacturers for resale in smaller volumes to retail outlets. Organisation 2a also specialised in the distribution of confectionary goods that it packaged for resale under its own brand.

Organisation 2a ran a sales order process whereby staff were employed to directly market and sell products from a basic layout and design (BLAD) style catalogue to the customer base. The term BLAD was colloquially used inside Organisation 2a to describe the catalogues that sale staff carried around in a suitcase to assist in the sales process. The catalogues essentially had product packaging pictures to assist the sales staff to describe the product and/or facilitate the brand or product recognition by the customer.

In support of the BLAD catalogue sales and marketing process Organisation 2a had also deployed the use of hand-held PDA style barcode scanners to assist the sales staff to process orders. This typically involved scanning barcodes from store shelves or within the BLAD catalogue and adding quantities.

Maintenance of the BLAD style catalogues incurred significant overheads, and they were bulky for the sales staff to transport and use in the sales environment. However, it was seen as an important marketing and sales facilitation tool by sales staff and management.

The sales order entry process was also seen as problematic and despite the use of barcodes, the process was slow, cumbersome and prone to human error in terms of stock and barcode selection.

As a consequence the BLAD catalogues and the sales order process were targeted for improvement or enhancement using information technology. The decision to innovate using information technology was driven by the business owners, who could see the opportunity presented by new developments in mobile technology. The business had already invested substantially in systems to manage the back office side of sales, inventory and warehousing, but no well-aligned solution existed to facilitate sales in the way the BLAD catalogues worked.

Whilst management recognised the potential for information technology to facilitate the desired business process improvements, Organisation 2a had no internal capability to progress the type information technology development required. To address this capability gap the business owners utilised a trusted business relationship to assist them in the selection of a potential "partner" to progress the development.

Organisation 2b was approached in 2006 and selected to progress the development. Organisation 2b was a micro-business of less than five employees that specialised in software development. Previous to the relationship Organisation 2b had limited development experience with sales order management in retail distribution, but had developed mobile applications in other business sectors.

The initial focus was on the design and development of a digital or electronic BLAD book that also provided sales order entry functionality. This development was undertaken at a time when wireless mobile broadband infrastructure was not widely available in regional areas. It was also undertaken at a time three years prior to release of Apple's ground-breaking iPad tablet. Organisation 2b had previous worked with mobile tablets in in the health industry and applied their experience to select devices that could work for sales staff at Organisation 2a.

Much of the initial development progressed with limited requirements documentation. Instead the development team relied on close collaboration with Organisation 2a's sales staff and business owners to gather requirements, test, and refine the design.

Development of the electronic BLAD books and the sales order entry was considered to be highly successful. The system allowed the sales staff to carry around up to date BLADs on a mobile computer. Sales staff could basically select items with the customer using the pictorial representations and order them immediately, or at least batch the orders for upload when communications allowed.

Although initially there was no plans to have the customer use the systems, customers showed considerable interest in the electronic BLAD books system because it was perceived as novel and cutting edge. Eventually customers were wanting to enter their own orders. This aligned well the high touch marketing approach undertaken by Organisation 2a.

Following a successful initial phase, new functionality was conceived to further enhance the system moving forward. Customer information such as previous product orders and billing status information were incorporated into the system. This greatly assisted the sales staff to setup their meetings with customers.

Next, additional functionality was requested to assist with the promotional marketing of products within the system. Organisation 2a regularly ran promotions around specific product combinations to maximise marge or targeted sales volumes. Organisation 2b possessed considerable experience with rule based expert systems. They transferred this knowledge, and some of the development techniques, into the electronic BLAD books system. Ultimately, this was to to organise the user interface to display and highlight optimal product order combinations and promotions.

Within three years the electronic BLAD books system had changed the nature of the relationship that Organisation 2a had with its customers. It had also optimised and refined the sales order and marketing processes. Customers had also become quite savvy with the mobile ordering approach and more comfortable with the technology.

Even in the initial phase some consideration was given to the development of a web based online ordering system, but it was rejected because Organisation 2a did not believe its customers were ready for such an approach. By 2010 this had changed, party facilitated by the customers exposure to electronic BLAD books system but also due to the advent of improved broadband internet penetration in regional areas. The release of numerous consumer based technologies (such as Apple's iPad) also shaped higher levels of information technology diffusion across the population in general.

As a consequence, the next phase had planned to include an online/web based electronic BLAD books ordering system along with client side "apps".

Both organisations had also started to recognise the potential use of the transaction data and customer interaction information they were collecting as part of the system. Proposals were also being assessed to incorporate sales intelligence and analytics into the system.

The electronic BLAD books system had a high level of integration with Organisation 2a's enterprise resource planning (ERP) system. This was recognised by the ERP vendor and the prospects for commercialising the system as a third party add-on were explored. For Organisation 2a, the electronic BLAD books system had become tightly integrated with their sales and marketing business processes, however the market assessment for the systems use in other organisations was unfavourable in terms of the price that the ERP platform market might be prepared pay.

In summary the electronic BLAD books system was considered to be a highly successful information technology innovation for Organisation 2a. The initial process had also facilitated a close collaborative partnership with Organisation 2b that gave Organisation 2a, unparalleled access to a software development capability.

4.3.1.2 Social structures

The direct benefits of innovation in Case 2 were appropriated by Organisation 2a, however innovation involved a collaborative partnership with an external software development business (Organisation 2b).

Table 4-4. Summary of actors and their roles in innovation in Case 2.

Actor	Description and role
Organisation 2a	A wholesale distribution business and the setting for innovation in Case 2.
Organisation 2b	Software development business providing development services for innovation in Case 2.
Organisation 2a business owners	Owners of Organisation 2a who signed off on high level requirements and provided strategic vision for the innovation.
Organisation 2b software developers	Third party software development specialists with expertise in rule based expert systems development.
Organisation 2a IT specialist	An in-house IT specialist who oversaw the systems operations and in later stages of development acted as a requirements broker between the business owners, sales staff and software developers.
Organisation 2a sales staff	Users of the system/software, who provided business requirements and feedback to on software suitability/fitness for purpose. Sales staff maintained the relationship and interface for feedback from Organisation 2a's customers (requirements brokers for customers).
Organisation 2a's customers	Provided feedback on system functionality and reliability via sales staff. Also referred to as independent retailers.

4.3.1.3 Information technology artefacts

Innovation in Case 2 involved the development of mobile tablet based sales ordering system. Whilst the software system was the central information technology artefact in place, there were a number of complementary information technology assets involved with the innovation.

Table 4-5. Summary of information technology artefacts involved with Case 2.

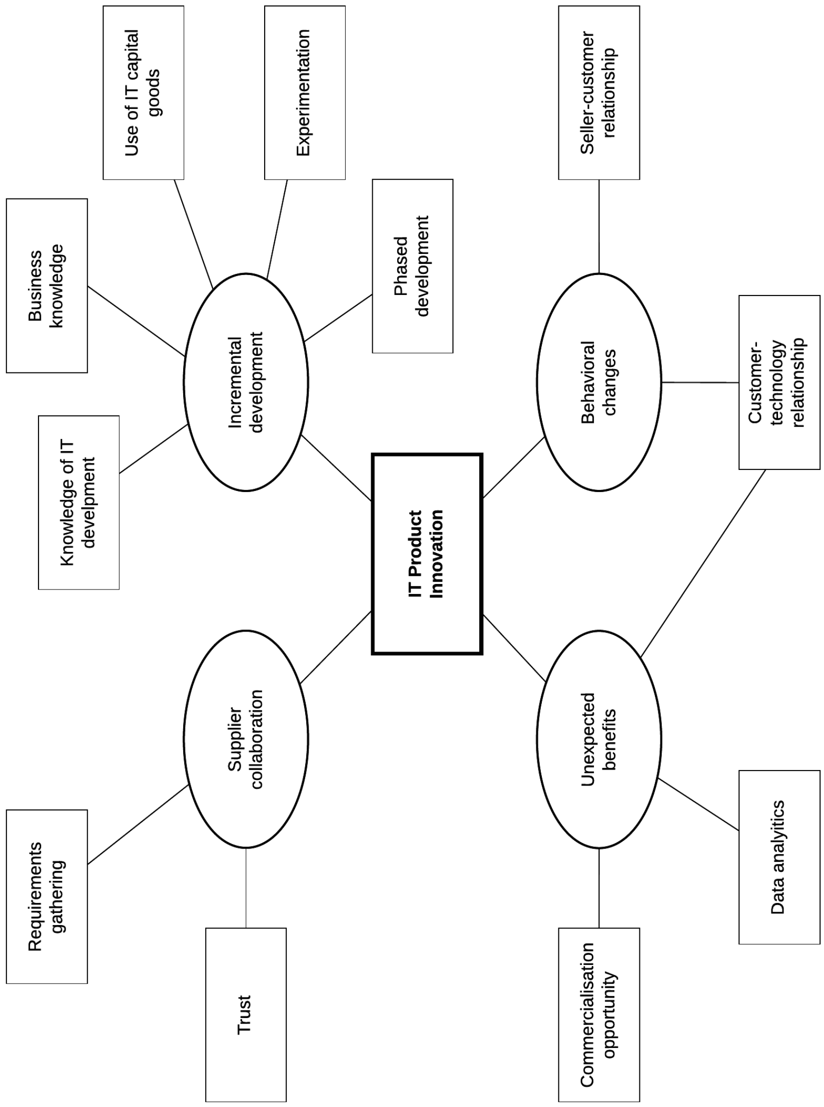
Artefact	Description
Mobile sales ordering software	The primary artefact was custom written software developed by Organisation 2b for Organisation 2a. The software was touch screen optimised to operate on tablet PCs.
Tablet computers	Ruggedized Windows based tablet computers were used by sales staff and eventually customers to run the mobile sales ordering software.
Organisation 2a's ERP platform	Organisation 2a had a COTS based ERP already in place and the mobile

Artefact	Description
	sales ordering software was designed to integrate with this platform.
Mobile communications networks	Mobile data communications were utilised to synchronise master data and transactions from the server to the mobile devices.
Application server infrastructure	Backend server based applications were used to integrate and deploy data between the sales ordering system and the ERP.
Sales data	Sales transactional data and sales ordering behavioural data was collected and positioned for further application through data mining and analytics.
System architecture	The combinational design or assembly of software, equipment and infrastructure that allowed the systems to function as a whole.

4.3.2 Emerging themes

Following a sequence of inductive coding and analysis, eleven themes emerged for Case 2 and were arranged into four groups of related content associated with the single global theme of information technology product innovation. Figure 4-2 illustrates the thematic network for Case 2.

Figure 4-2. Case 2 Thematic network.



The global theme of *information technology product innovation* pertains to the development and successful use of a novel information technology solution within the organisation. The themes and their groupings in the network are summarised in table 4-6 below.

Table 4-6. Case 2 emerging themes

Organising Theme	Theme	Definition
Supplier collaboration	Requirements gathering	Collaboration with suppliers to inform and generate requirements for the system.
	Trust	Development of confidence in the supplier to work

		towards the best interests of Organisation 2a .
Incremental-development approach	Knowledge of IT development	The incorporation and application of information technology techniques and methods to engineer the system.
	Business knowledge	The incorporation and application of business knowledge, particularly of the business processes required to design an acceptable system.
	Experimentation	Testing ideas within the system to determine the impact and effectiveness for specific requirements.
	Use of IT capital goods	Incorporation or integration with commercially off the shelf software and equipment.
	Phased development	Distinct stages of development characterised by the incorporation of new high-level system functionality.
Behavioural changes	Seller-customer relationship	Behaviours or practises of sellers that are associated with selling products to the customers.
	Customer-technology relationship	Behaviours or practises of customers in relation to their attitudes toward the role of technology in their business.
Unexpected benefits		The benefits associated with changes in behaviours or practises of customers in relation to their attitudes toward the role of technology in their business.
	Data analytics	The use of data to generate greater insight into sales activity and customer ordering behaviours.
	Commercialisation opportunity	The opportunity to sell the system to other organisations.

4.3.2.1 Supplier Collaboration

Innovation activity associated with the development of the mobile sales order entry system involved a high degree of collaboration with a third party software development organisation. Organisation 2a had no information technology development capabilities of its own. The relationship it ended up establishing with the third party developer (Organisation 2b) was highly interactive and based on trust.

P2b: "It would have helped us if we had a spec, but I think they would have struggled, they don't have the time and resources and sit down and do the spec. But they believe solidly in what we can do and there is a sense of trust between us and them, so much so that they give us the benefit of the doubt in terms of what ever we are going to do to achieve the outcome is. That is significant in this process, so at the end of the day its like I said, we trust you in what you do, we you are doing your best in our interest and that's great.

It appears that Organisation 2b was able to establish an environment of trust through the delivery of useable outputs in the initial phase of development.

The collaborative relationship was a critical factor in the success of this innovation, but it did not appear to be as effective from a software engineering efficiency perspective. However the developer cited the process as being very effective for delivering creative and innovative solutions.

P2b: "Its different, if we were to do this project say with another client who we don't have a relationship with and that finding your feet, then obviously to manage risk then you go and write a tighter specification, but that stretches the development of the innovation I would say somewhat. It may even limit the creativity that's involved as well."

Organisation 2a appeared to have realised the importance articulating the requirements. During the latter phases of this innovation Organisation 2a employed a person with an information technology background to work in the business, with the sales staff and assist with requirements gathering.

P2a: "I get feedback from sales reps. I've basically filtered up what's doable from the technical perspective and then I've passed it on to [the programmer]."

It is unclear if the introduction of this role was effective in articulating more accurate requirements, however it may have been effective in assisting time poor sales staff to test and provide feedback to the developers.

4.3.2.2 Incremental development approach

Development activity associated with Case 2 was decidedly phased and incremental. Activity was phased in terms of at least four stages of development. Each phase appeared to been set high level goals or objectives from which a series of incremental plan, design, code and test sequences were performed in close collaboration with stakeholders. In the initial phase additional work was performed selecting and testing suitable equipment.

P2a: "Constantly changing, evolving there is new requirements that we have every week. Obviously we have the major features in mind and that's documented in a requirements document, but other than that the added features and fixes is a process, its grinding."

During the incremental sequences knowledge of the business processes, such as the use of graphical/pictorial sales and marketing techniques (BLAD books) where combined with the knowledge of software engineering. Organisation 2b also appears to have incorporated advanced software methods and techniques to manage the promotional functionality within the system; and new mobile user interface design ideas to facilitate ease of use on tablet computers. The process also involved the integration of mobile technology and the interfacing of transactions and master data with Organisation 2a's ERP system.

P2b: "But Robbies always understood from an early stage that if you had a picture of the product, particularly with their line of goods it was easy for them to sell."

P2b: "If you look at the application it looks very sleek and its easier to use it on a tablet, but if you were to use it on a notebook or on a desktop its actually from a usability point of view, its probably not optimised. The whole emphasis initially was to replicate this manual, what we call Blad books, suitcases of information, replicate that business process."

Participant 2b also described the incremental elements of the development process as experimental, with ideas and changes being a hit and miss affair.

P2b: "So it has been an evolutionary, because they are eager to kind of experiment in a way. We were lucky, they got good value from their investment and they are still willing to tweak and turn but there has to be a return."

P2b: "There are couple of times we have tried things that they wanted, it was quite complex to get things done and they just went, no this is no working how we wanted to do and they don't want us spending more time or money on it, just cut it off."

During the early stages of development elements of the design were also influenced by (1) the lack of availability of mobile wireless services in regional areas; and (2) the perception that their customers would be reticent to take-up a web based online ordering system.

P2b: "That is something see in the future but knowing how poor the internet penetration is in Tasmania, it may happen, but service regional areas as well. It's also the reason why we synchronise and have a local database, simply because we can't get 3G coverage. Despite what [removed] claims."

4.3.2.3 Behavioural changes

A striking outcome from the information technology innovation undertaken in Case 2 was the reported change the software deployment had facilitated in the behaviour of sellers and customers.

The first reported change was for selling, in particular the relationship between seller and customer. The new sales ordering system transformed the nature of the sales order entry and the interaction that the sales staff had with the customer. The implementation of smart promotional emphasis and bundling of "deals" improved the overall profit margin gained by organisation 2a. The graphical/pictorial user interface provided for a richer interaction with the customer and because the order processes was now more efficient and interactive, sales staff could spend more time marketing to the customer, rather than entering orders. Furthermore developments that incorporated customer histories and billing information assisted the sales staff to focus on the right products and manage outstanding debts.

P2b: “So in effect the sales team their duty is to change the balance between branded and non-branded and then hence increase margins and profitability on each order. So what we did there is we tweaked therefore then the system to promote non-branded packages and opportunities before branded, provide the necessary tools to assist the sales people with that business need.”

P2b: “So that’s effectively the conclusion of the major works, that was where we left it and that has been running now for two years and as I said that’s changed their business in terms of turnover, because of this branded and non-branded scenario.”

The second change pertained to the customer’s attitudes towards technology use in the ordering process. During the initial phase of development reservations were cited in relation to Organisation 2a’s customers being ready to adopt online ordering. After exposure to the new sales order system developed as part of the innovation in Case 2, attitudes towards the use of technology appeared to have changed in part by exposure to the system. Whilst such a phenomena would undoubtedly be influenced by consumer technology trends and technology diffusion in general, there are accounts of customers becoming involved and actively participating in the sales order process. This process facilitated a desire to undertake the order process themselves. Changes in the customer behaviour and attitude towards technology in their business ultimately led to the development of a self-service web based module that was introduced in a subsequent phase.

P2b: “The novelty factor got to a stage where some of the customers thought the order system was fun to use, the interface was very easy to use let me do my own order. So it got to a stage where the sales guys would turn up and say, if this is what you want to do here you go on the counter and the client, the customer themselves would actually do their own order and then the sales guys would spend this time upselling, not ordering.

4.3.2.4 Unexpected benefits

As development progressed in Case 2 a number of unexpected benefits were obtained by both organisations involved in the innovation.

The customer-technology relationship described in the previous section (4.3.2.3) was not a deliberate objective of the original decision to innovate, however it established Organisation

2a as a technological innovator in the eyes of its customers and allowed its customers to experience the potential usefulness of information technology in their relationship with Organisation 2a.

An opportunity presented itself for commercialisation of the new sales order system. This opportunity arose with the vendor of Organisation 2a's ERP platform. The opportunity was investigated but found to fit into a difficult pricing bracket that offered limited return on investment. Both organisations acknowledged the potential but at the time of interviews had held off on developing it further.

P2b: "Its not something that we set out to do, its something that we kind of stumbled upon. The novelty and innovation that was shown there is still missing in the marketplace. One thing that is interesting is that the commercialisation pathway, the return on the commercialisation pathway is miniscule so, I would say the commercialisation of this product you would be looking at less than 2 or 3% of the investment, to commercialise this product we have got to go for volume and that's a hard thing to swallow."

Both organisations also realised the potential to utilise transactional data and possibly its metadata to provide analytical insight into the detailed ordering behaviours of its customers and the sales ordering activity of its sales force. Again, the use of data in this way was not part of the original design objectives.

P2b: "One other area, although we haven't implemented it yet was the sense of a sales intelligence tool. We have the capacity to actually monitor where the sales people are, how much time they are spend with the customer and if we wanted to get down to the levels, actually what they do with the customer. We sensed we have the capability to actually record the whole interaction; we can play that back in real-time."

4.4 Case 3 – Aquaculture production control software

4.4.1 Context

4.4.1.1 Innovation activity and events

Case 3 investigates information technology innovation associated with the development of an aquaculture production control system for a vertically integrated aquaculture business focused on the production and distribution of farmed Atlantic salmon (Organisation 3). The innovation in Case 3 is characterised by a software development initiative that commenced in 2000 and was nearing the end of its lifecycle in 2013.

A single interview was conducted with an employee who was involved in the system development and had continually utilised the system through its entire lifecycle.

Organisation 3 was a large (by Australian standards) aquaculture business that farmed and processed Tasmanian Atlantic Salmon. The business had grown from a small operation in the 1980s to a multi-million dollar business, producing more than 15,000 tonne of salmon a year and employing over 500 staff.

Growth in Organisation 3's production presented the business with problems tracking fish and understanding the costs associated with farming. Farming salmon in the south east of Tasmania also required the business to move the fish in and out of seawater and regularly bath the fish in freshwater in order to combat the detrimental impact of an amoeba that was present in marine environment.

Prior to the development of the aquaculture production control system that forms the basis of IT innovation in Case 3, farming activity and production information was tracked by several large and unwieldy spreadsheets. Realising the constraints of the spreadsheet approach management initiated a project to develop software to centrally manage farm activity data, in particular bathing activity and fish movements. Consideration was given to utilising commercial off the shelf software (COTS), but the need to track bathing activity was unique to the Tasmanian environment, and the functionality to track fish movements was limited if not absent from the available COTS products at the time.

Development of the production control software commenced in 2000. Software development was outsourced to an independent third party developer. By all accounts, there was never a formal high-level software specification provided to the developer. Instead, requirements where incrementally specified by a small team that included the two senior farm managers and another staff member that acted in a business analyst type role. The business analyst gathered the requirements and documented these using data collection templates or forms. The business analyst then facilitated revisions with other stakeholders before handing over to the developer. The process was interactive, with the templates being continually revised between the senior farm managers, other farm stakeholders, and the software developer. This process was also iterative, being repeated back and forth until an agreement was formed between farm management and other farm stakeholders.

Requirements continually evolved. The systems scope was never formalised and it appeared to expand in an unstructured manner to cover more facets of farm production. Complexities began to emerge and as a consequence the development process took up to two years before a fully operational system was deployed to the farm.

Deployment and implementation was seen to be problematic. The system design appeared to be very focused on collecting data but not very effective at providing information back to operational staff in a clear and concise manner. Some staff continued to run "shadow systems" to meet their operational needs, whilst other (analytical) staff devised methods of taking data from the system and manipulating it for their needs.

After many years of use, ongoing additions and modifications, Organisation 3 had amassed a considerable data history of its operations. This information asset was able to assist the organisation on several occasions when there were issues in production. The same asset was, by circumstance, not available to Organisation 3's competitors and became a source of temporary competitive advantage.

Organisation 3 eventually recognised the need to provide better reporting for operational decision-making. In 2005, in conjunction with an ERP initiative, Organisation 3 deployed a web based business intelligence platform throughout the business. This platform became the standard for graphical and tabular reporting, and was subsequently utilised to improve data use within the production control system.

However, by 2013 the production control system was no longer meeting the needs of the organisation as the software platform supporting the system was reaching end of life. Farm operations were changing and becoming more generic, and the aquaculture software marketplace had consolidated and added new functionality to support the type of transactions associated with bathing treatments. In 2014 the software was retired and replaced with a COTS platform. The data was consolidated and restructured in a manner to support ongoing analytical work that could be integrated with the newly introduced system.

4.4.1.2 Social structures

Innovation in Case 3 involved number internal structures within Organisation 3 lead primarily by senior management within the business with software development completed by an external software engineer.

Table 4-7. Summary of actors and their roles in innovation in Case 3.

Actor	Description and role
Organisation 3	Vertically integrated aquaculture organisation and setting for innovation in Case 3.
Senior management team	Senior management where highly involved in specifying software requirements to the business analyst.
External software engineer	An external software engineering specialists responsible for coding from specified requirements.
Business analyst/project manager	An in-house staff member responsible for documenting and brokering the requirements with senior management, operational users and the software engineer. The role was also a quasi project manager responsible for coordinating the development.
Operational staff	Users of the system/software, who mainly provided feedback on the system as to its suitability and fitness for purpose via the business analyst/project manager.

4.4.1.3 Information technology artefacts

Innovation in Case 3 involved the development of an aquaculture production control system. Whilst other complementary information technology assets were involved they were not covered in the interview transcripts to any great extent. Field notes provided additional information concerning the related information technology artefacts.

Table 4-8. Summary of information technology artefacts involved with Case 2.

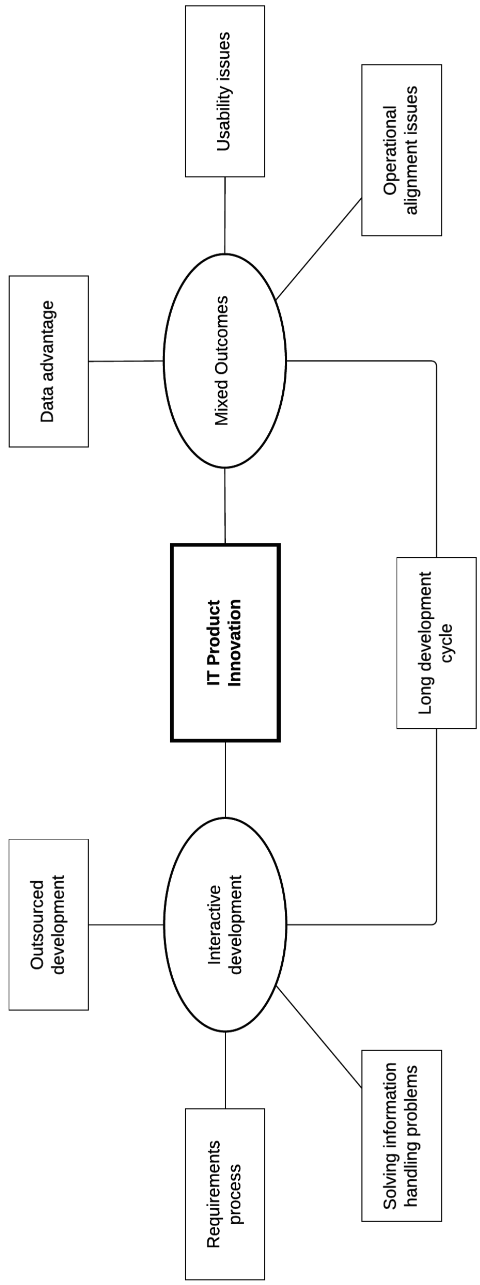
Artefact	Description
Aquaculture production control software	The primary artefact was custom written software developed specifically for Organisation 3's requirements around aquaculture operations and production.
Software development framework	A customised software development framework designed to work Microsoft's Windows SDKs and database platforms was developed and used by the software engineer (best described as CASE tool).
Database management systems	The MS SQL database management system (DBMS) was deployed to manage data associated with the software.
Microsoft Excel	Microsoft Excel was used extensively in support of the application, not by design but by virtue of perceived reporting shortcomings.

Application server infrastructure	Backend server applications were used host the client side software and backend DBMS.
Farm production data	Large volumes of production and operations data was collected and utilised in an analytical capacity to support decision making.
System architecture	The combinational design or assembly of software and infrastructure that allowed the systems to function as a whole.

4.4.2 Emerging themes

Following a sequence of inductive coding and analysis, seven themes emerged for Case 3 and were arranged into two groups of related content associated with the single global theme of information technology product innovation. Figure 4-3 illustrates the thematic network for Case 3.

Figure 4-3. Case 3 Thematic network



The global theme of *information technology product innovation* pertains to the development and successful use of a novel information technology solution within the organisation. The themes and their groupings in the network are summarised in table 4-9 below.

Table 4-9. Case 3 emerging themes

<table>
<tr><th>Organising Theme</th><th>Theme</th><th>Definition</th></tr>
<tr><td rowspan="4">Interactive development</td><td>Solving information handling problems</td><td>Development activity was concerned with solving problems associated with the collection, storage, processing and distribution of information.</td></tr>
<tr><td>Outsourced development</td><td>An external third party undertook information technology development.</td></tr>
<tr><td>Requirements process</td><td>A deliberate formal requirements process was used to elicit requirements from stakeholders and filter them to the developer.</td></tr>
<tr><td rowspan="2">Long development cycle</td><td>Development outputs took a long time to complete.</td></tr>
<tr><td rowspan="4">Mixed outcomes</td><td>The benefits of development were delayed longer than anticipated.</td></tr>
<tr><td>Operational alignment issues</td><td>Development outputs were not fully aligned with the operational (farming) needs.</td></tr>
<tr><td>Usability issues</td><td>Many users found the system difficult to use.</td></tr>
<tr><td>Data advantage</td><td>Business advantages were gained from the creation of historical data resources.</td></tr>
</table>

4.4.2.1 Interactive Development

System development for the aquaculture production control system was an interactive process involving various stakeholders. It was focused on solving an information-handling problem that was present in the farming operations of Organisation 1.

Organisation 3 had progressed through a period growth where information was being recorded but in a manner that was difficult to utilise for consolidated operational decision-making. In effect the IT innovation decision taken by organisation was linked to solving an information or data handling problems.

P3: “The drivers for it was that the business was growing, more and more information was coming in because we had more units and it was a way of logging all that information so it was readily accessible, so that you could track back and look at different things. “

P3: “All the information was kept on XL spread sheets and some of them were getting too big and unwieldy and there was a hell of a lot of transactions going on because in the early days there wasn’t much bathing, like you might only bath the fish three times in a cycle, no its up to eight times.”

To solve the problem Organisation 1 it was understood that a centralised system was required to collect, process and report information collected on the farm. Organisation 1 evaluated existing systems that had been used elsewhere in the aquaculture industry, but came to the conclusion that the available systems where not well aligned to the processes undertaken in the Tasmanian marine farming context. A decision was made to develop a purpose built system. At the time, Organisation 3 had no internal software development expertise and sourced the development externally (outsourced) via a third party developer. From examination of documentation and field notes the third party was a sole operator and virtually dedicated himself to the development of the aquaculture production control system. It was also evident that the third party developer was able to retain and utilise the intellectual property associated with the development and attempted (with minor success) to commercialise the system with other aquaculture operations.

The ongoing development process was characterised by an unusual dichotomy in the requirements specification and elicitation process.

On one hand, there was a relatively formal requirements gathering process that involved interactions between management, operational (farm) stakeholders, and the developer that was facilitated by a business analyst (the title was not explicit with Organisation 3). The business analyst used a series of templates or forms that outlined what data it was proposed to collect and manage within the system. The design of these templates went back and forth between senior management and operational stakeholders. Once they had agreement or management decided that was the final design, the business analyst would pass it on to the developer to implement as software and as a database. Following this there then appeared to be a process of feedback and testing to "fine tune" the software design.

P3: "[the business analyst] was taken on to do that, she was the facilitator who would go to the guys revise the template, go to [the developer] get him to do it, go back …"

On the other hand, and in contrast to the detailed development work, there was no formal high-level goals or requirements planning. In effect the development was largely unplanned and unstructured in terms of the high level deliverables.

P3: “The original plan was in [managements] head …”

P3: “It grew like an English village, so rather than with a town planner little bits were tacked on. The nature of that was the way [management] thought I think, without incriminating myself. Because each time it was reviewed [management] would come up with more things they felt that they wanted to record, where as the [farm] mangers tended to look at it and try and simplify things but [management] would add more information fields on. My view is that’s how it took a very long to get to a level where we could use it on the farm.”

Whilst Organisation 3 ultimately produced a working software solution, both processes appeared somewhat flawed and were linked to (1) a long development cycle – the software taking a long time to be placed into operations; and (2) it had operational alignment issues – the software was data collection driven and did not meet the reporting needs of some areas. Both of these issues are discussed in the following section (4.4.2.2)

4.4.2.2 Mixed Outcomes

Development appears to have taken considerably longer that stakeholders were expecting.

P3: “It did take a long time, you would have to speak to others to get the time scale, from memory I think it took a couple of year from concept to getting something we could use on the farm and then it was another two years (probably) of modifications.”

The primary cause for the long development cycle appears to have been a continuous growth in the scope of what the system would do (scope creep) and this was allowed to occur because no controls had been set by management (intentionally or otherwise). The formal requirements process may also have impacted the cycle.

P3: “What we found was it took quite a long time that revision processes …”

Despite the long development cycle Organisation 3 did achieve some of its desired outcomes.

P3: “but we ended up with a database that was very applicable to our operations rather than getting some generic one…”

Operational alignment was one of the main reasons that Organisation 3 chose to build a system from scratch rather than use commercial off the shelf software. Interview transcripts provide evidence that operational alignment was only really achieved in terms of data collection and having the data stored centrally. But even elements of the data collection appear to have been compromised by adoption problems.

P3: “With hindsight when you look at it there are a lot of reports and a lot of fields not used.”

One of the main issues cited in the transcripts was that the software actually had a number of shortcomings in terms of useability. At the operational level users found it difficult to obtain decision-making information back from the system after collecting and recording operations data. The user experience entailed additional manual handling of the data in order to summarise and/or visualised the data in a format that facilitated decision-making. Referring back to the requirements process, this may not be so much unsurprising, as the development focus was on data collection and not what the user wanted to see in the end.

P3: “I mean it’s got a lot of shortcomings but I actually think a lot of the shortcomings are about data handling. The data goes in there and you’ve got your fixed AA report but to do anything with it you’ve then got to download it into Excel and play with it …”

This issue was addressed in later years with the establishment of a separated business intelligence and reporting platform.

P3: “Business Objects [Reports] are better, working with [removed] she is able to have automatic collation fields where you’ve got different categories and different graphs, so rather than just the raw data you’ve already got useful reporting.”

One area where the system provided distinctly beneficial outcomes was with the establishment of a central repository for all the farming data. After a few years Organisation 3 managed to build up a significant resource in historical production data. This data provided a competitive advantage over its competitors at the time, because the same resource was unavailable to its competitors. Having access to the resources was cited in once instance as being pivotal for solving a serious production problem long before its competitors.

P3: “That was really one of the strengths of the business in that all the information and data sheets had all been kept right from word go …”

P3: “We ended up solving the slow growth issue much quicker than the others and my view is having all that past data was the strength and verses [our competitors]”

4.5 Case 4 – Tourism online sales and inventory middleware implementation

4.5.1 Context

4.5.1.1 Innovation activity and events

Case 4 investigates the implementation and deployment of a middleware integration platform to facilitate automation of online sales and inventory management by a large tourism and accommodation services operation (Organisation 4).

Organisation 4 was a large and mature organisation with more than 1,000 employees. It had a dedicated information technology function with more than 20 qualified information technology professionals on staff.

In 2005 the marketing division of the Organisation 4 initiated a "place branding" strategy that aimed to market experiences at locations where Organisation 4 operated its travel and accommodation assets. The new marketing strategy included use of online communication channels (i.e. property web sites in conjunction with various online travel and accommodation intermediaries). The initial phase of this strategy included a brand redesign and the establishment of a number of websites linked to key property and destination assets. Initially the development and hosting of websites was entirely outsourced.

Concerned with local availability of reliable hosting services, the organisation procured services from interstate service providers to maximise availability and performance.

During the initial phase in the initiative there was some uncertainty pertaining the overall potential for success, and the use of the online channel to support it existing business model. Because of this uncertainty the organisation focused its efforts on web site development and the establishment of supporting online services. Back office business process that supported order processing, inventory management and ticketing were left to manual tasks. Orders were processed by email, with bookings and inventory updated manually in the property management systems, and with the various website and services. The initial phase proved to be very successful, with up to 5% of all sales being captured online within two years of commencing the initiative. The organisation also won a number of tourism and web design awards.

As online sales began to increase it became evident that the effort required to maintain the back office systems for order capture, accommodation inventory, ticketing would become unsustainable.

The organisation responded by entering a new phase of IT innovation and commenced search solutions to integrate the new online sales channels with the various back office operational systems. The technical team found a candidate middleware solution that used web services to update inventory between accommodation service providers and various online booking intermediaries.

The technical team assessed the middleware solutions suitability for integration with its own booking and inventory management systems. Happy with the prospects for success, the organisation progressed with an implementation initiative using the middleware solution to provide the associated interfaces for the software to manage its accommodation inventory between back office systems, websites and third party intermediaries.

In progressing the development of interfaces between systems, technical staff worked closely with the middleware vendor, internal marketing staff, and the customer services staff that operated the various online systems. Technical staff took on the dual role of business analyst and software developer. Interfaces for the various online transactional systems were developed using .Net web services and platforms that the organisation had already established to support existing operations. Detailed planning and development of a data warehouse was also undertaken to support the systems integration work.

After three years, sales capture via online channels had increased significantly. IT staff were now intricately involved in its ongoing development and operation. The organisation appointed a project manager to progress with new work and the organisation introduced new change and user acceptance testing procedures to support ongoing development.

The overall initiative was considered a resounding and ongoing success. Innovation involving the use of IT for systems integration contributed significantly to the economic and operational sustainability of the place branding strategy. Automated workflow had reduced the overheads associated with updating some 16 different websites and various back office systems down to a process taking about 10 minutes.

Discussions were also held about selling the intellectual property associated with the systems integration to a similar international concern, along with the prospect of including external bookings, inventory, and ticketing from affiliated third party tourism operators operating in the same areas as the case study organisation.

4.5.1.2 Social structures

Innovation in Case 4 involved number internal structures within Organisation 4, lead initially by a marketing initiative and then via IT leadership to integrate and streamline various inventory management systems.

Table 4-10. Summary of actors and their roles in innovation in Case 4.

Actor	**Description and role**
Organisation 4	A tourism and accommodation services operation and setting for innovation in Case 4.
Marketing department	The marketing department initiated the innovation with a strategic vision. Largely drove the initial stages themselves with only minimal input from IT specialists.
Internal IT specialists	Internal IT specialists undertook architecture and design roles for systems integration. They also configured and deployed the platforms used for managing inventory and integration. They facilitated testing and articulated requirements from internal customers and communicated specifications to external software vendors where required. Internal IT specialists also deigned, configured and deployed the enterprise data management models and systems.
External software vendor (suppliers)	External software vendors provided the main integration platform and provided development and configuration support.
Internal business customers (users)	Internal business customers (users) provided requirements and testing feedback to internal IT specialists.

4.5.1.3 Information technology artefacts

Innovation in Case 4 involved the implementation and deployment of a middleware inventory integration platform in support of a marketing strategy. There were a number of information technology artefacts involved in this innovation.

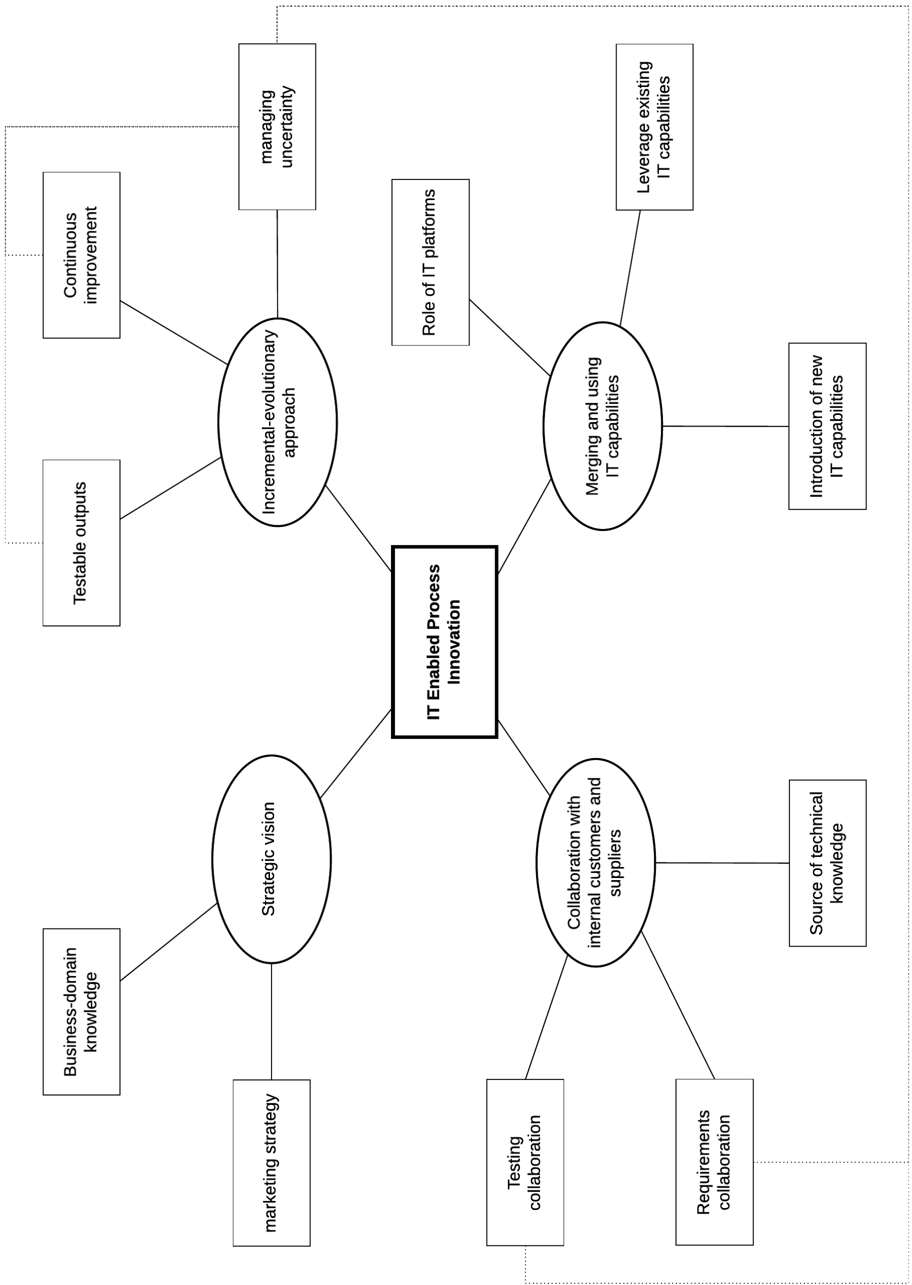
Table 4-11. Summary of information technology artefacts involved with Case 4.

Artefact	**Description**
Inventory integration middleware	Software configured and deployed to synchronise and publish property to online services and internal systems.
Existing property management systems	Existing software systems used within various parts of the business to manage different types of properties or experiences.
Database management systems	Database management system (DBMS) deployed to manage data associated with all the software.
Data models	Metadata for the design and description of information assets used to support systems and information transfer.
Application server infrastructure	Backend server applications were used host the client side software and backend DBMS. Including externally hosted systems for web site and related applications.
Web site	Online web sites to facilitate the Organisation 4's online branding strategy.
Online booking services	Various online booking brokers or agencies that allowed inventory to be sold on behalf of Organisation 4.
System architecture	The combinational design or assembly of software systems and infrastructure that allowed the systems to function as a whole.

4.5.2 Emerging themes

Following a sequence of inductive coding and analysis, eleven themes emerged for Case 4 and were arranged into four groups of related content associated with the single global theme of information technology enabled process innovation. Figure 4-4 illustrates the thematic network for Case 4.

Figure 4-4. Case 4 Thematic network



The global theme of *information technology enabled process innovation* pertains to the modification and novel use of information technology to facilitate a business process innovation. The themes and their groupings in the network are summarised in table 4-12 below.

Table 4-12. Case 4 emerging themes

Organising Theme	Theme	Definition
Strategic vision	Business-Domain Knowledge	Knowledge of the business and its market were used to create a vision for innovation.
	Marketing Strategy	A deliberate plan was developed around longer term marketing and branding objectives.
Incremental-evolutionary approach	Continuous improvement	An iterative process was employed to refine the design and output of innovation activities.
	Managing uncertainty	Specific mechanisms were employed to address uncertainties in the development process and outcomes.
	Testable outputs	The outputs of incremental innovation activity produced outputs that could be tested in business operations (by the internal customer).
Collaboration with internal customers and suppliers.	Requirements collaboration	Collaboration between internal customers and external suppliers with respect to the business requirements or fitness for purpose (quality).
	Testing collaboration	Internal customers and suppliers were involved in the testing process.
	Sources of technical knowledge	Operational and technical knowledge was sourced internal customers and external suppliers to progress the innovation.
Merging and using IT capabilities.	Leveraging existing IT capabilities	Existing information technology assets and capabilities were used to progress innovation.
	Introduction of new IT capabilities	New information technology assets and capabilities were introduced to progress innovation.
	Role of IT platforms	Specific information technology assets were being used for multiple purposes or application.

4.5.2.1 Strategic vision

A decision to change the marketing strategy and promote place and experience over product and service features was an important feature of the innovation. It was enabled by information technology but the information technology initiatives also remained aligned to the objectives this strategy throughout the lifecycle of the innovation.

P4: "…so they were really looking at getting, trying to increase their brand presence, trying to provide a service that they saw a lot of people weren't necessarily providing, things like itinerary planning in the web site, so you could go and log on to the website and plan your itinerary actually save that and come back later the next [time] and adjust your itinerary and relook at that and re-manage that. That was fairly unique as far as website went."

Knowledge of the business domain and the markets in which it operated were used to develop the core concepts of how information technology could be configured and deployed to exploit a unique opportunity for the business. This knowledge was also used to drive the initial information technology choices for case 4.

P4: "Went out to about five or six different vendors, some of those Tasmanian some of those mainland vendors, In the end they decided on a mainland vendor because they had the best understanding where they wanted to take the brand."

4.5.2.2 Incremental evolutionary approach

The innovation was continuously delivered over several years in small manageable stages. Each stage improved upon the previous, optimising the initial concept by either building on its success or addressing a problem with the initial solution design.

I0: So a lot of incremental adjustment through process and possibly a pathway or roadmap that does not necessarily see an end yet?

P4: That's rights. So what we are doing now is rewriting a lot of the website back end to take out a lot of the hard coding aspects of the website so we are driving a lot the content now, on the website from our backend property management solutions. If we had new room types or add new properties we can drive a lot of the information from that on to the web site via our backend property management solutions rather than having to get the web developers to add new pages and redevelop the website."

The incremental approach also appeared to be influenced by two different types of uncertainty – (1) uncertainty about the outcomes and whether the concept would be successful or otherwise; and (2) uncertainty about the requirements and how best to approach the innovation.

P4: "There wasn't a lot of I guess "they didn't know what they didn't know" to start with …"

The issue of uncertainty in requirements and outcomes was also linked to a focus on producing "testable outputs". The incremental delivery of real operational outputs allowed Organisation 4 to test the feasibility of technology solutions and marketing strategy. Testable outputs also allowed internal customer to elaborate the requirements for the next stage of improvement and better conceptualise how to put the technology to operational use.

P4: "We saw a lot of areas where the website was being set up with a lot of hard coded information so it wasn't getting written by the back end systems, but they didn't want necessarily spend the money up front to get that going because they weren't sure if the website would be a success. Let's just get the website out there operating, in a marketing sense operating like how we monitor it and then we will come back and re-look at the back end processes, re-look at getting that automation process being stitched."

4.5.2.3 Collaboration with internal customers and external suppliers

Internal customers drove the business requirements for this innovation. However throughout the lifecycle of this innovation there was a high degree of collaboration between internal customers and information technology professionals (developers).

P4: "The developers do a dual role, the business analyst and the developer role…but we work very closely with the marketing departments…"

In some instances the developers were external professionals (suppliers).

External suppliers also assisted to manage the complexity of configuration and deployment in several instances. This collaboration enabled the development of appropriate implementation and deployment methods, ultimately contributing to successful innovation outcomes.

I0: "Was that complex or a relatively simple install process?"

P4: "Reasonably complex."

I0: "So it wasn't just a straight forward process you had some consultants come in to assist?"

P4: "We did it with the vendor basically. Our development teams worked closely with the vendor to do that."

The internal information technology team consciously pushed internal customers to participate in testing processes and discovered its full utility as the innovation evolved.

I0: "Does testing follow a formalised process?"

P4: "Not as formal as I would like it, but we have certainly formalised it a lot more than what we had. Sometimes you bring the front end users kicking and screaming to the table and that and they just want to put it in, but you test that it does what you want it to do."

Collaboration ultimately sought knowledge of technology and process. Business operational knowledge was sourced predominately from internal customers, whilst technical knowledge of information technology methods and processes was sourced from a combination of internal information technology development staff and external suppliers.

4.5.2.4 Merging and using existing IT capabilities

Organisation 4 was endowed with a broad range of pre-existing information technology capabilities and a great portion of innovation activity was fulfilled by leveraging existing information technology assets.

P4: "… the strategic direction was basically fulfilled by the technologies we had and we didn't have to do anything new."

In-house development skills were used for interfacing to back office systems and developers combined as business analysts to work with internal customer on user requirements.

Despite initial claims that they "didn't have to do anything new" it is apparent within the transcripts and field notes that there were a number new and complementary information technology capabilities introduced during the lifecycle of the innovation. New middleware software was introduced to perform inventory updates between systems. A new development, testing and production cycle was introduced to manage changes and releases of software updates and new practices developed for prioritising information technology were taken on.

P4: "so now its standard that we have a development, test, UAT, production type environment that we've never had before."

Capabilities and assets were also merged into the innovation from external sources. The website design and development process was entirely outsourced, with little internal information technology staff influence. An external vendor was also engaged to assist with product configuration and interfaces associated with the middleware endpoints.

Another important capability that emerged from the merging of new and existing capabilities was the development of a platform that could be used or scaled for broad business application. The middleware integration technology provided a capability to automate and simplify inventory management across a range of systems and related businesses and thus became a source of continuous innovation.

P4: "A lot of the backend systems that we looked at were really focused on the single areas. There are a lot of property management solutions that will work from the front end to the backend, but they don't cater for things like ticketing solutions and shows and boat trips etc. There is a lot of ticketing solutions but they don't cater for the accommodation side of things. What we are also trying to do with the website is to bring in things like new channels. We would bring in our business customers on a different channel, with different rate structures they can book online via the website with their own rate cards. We are also looking at bringing in a travel agents channel that travel agents can actually book online. They would also get the appropriate rates and we would obviously give them the right conditions for that stuff. We are even thinking about eventually is that we will get away from using the front end client on our applications like our property management and ticketing solutions and we would give our customer contact centre and club desks and those guys just the web front end so they can just use the single front end for all there the booking of their guests. They won't have to jump out of multiple systems. The end game is to have that single interface no matter who the client is."

4.6 Case 5 – Application of LIDAR in forestry resource management

4.6.1 Context

4.6.1.1 Innovation activity and events

Case 5 investigates information technology process innovation in the forestry sector. It follows the introduction of light detection and ranging (LIDAR) data collection technology, and its integration with other technologies and processes to provide a system for broad scale forestry management.

At the time of study Organisation 5 was a large enterprise responsible for the sustainable management of forestry resources used for timber production, conservation and tourism.

Organisation 5 was facing a number of issues in relation to the collection of data associated with inventory measurement. Since the early days of its inception Organisation 5 had been using aerial photography to examine forest structure. Interpretation of these photos provided estimates relating to the type of forest and its volume. The problem with aerial photography was that it was expensive and it required skilled interpreters. Interpreters took a long time to train, delivered inconsistent results, and were increasingly difficult to find due to an emerging skills shortage.

In 2002 after many years watching developments in remote sensing technology, the emergence of LIDAR technology caught the attention of researchers at Organisation 5. LIDAR uses light waves to measure the distances from an optical sensor to an object. In a remote sensing application, lasers on-board an aircraft can be used to illuminate objects on the ground whilst an optical sensor (also on-board) measures and process the reflections. In a forestry application, light waves could be directed at forest vegetation and initially reflected off the forest canopy, then from other underneath the canopy down to ground level. The nature of the reflections would allow vegetation to be discriminated from the ground and provide highly accurate spatial data about the height, structure, and density of a forest. LIDAR had been previously used extensively in mining applications to map the ground topography. Reflections from vegetation were seen as “noise” that needed to be filtered out.

Organisation 5 viewed LIDAR as a viable method for inventory measurement and in 2004 made the decision to conduct a number of experimental trials over different forest types to determine if the application of LIDAR could actually be used to assist with inventory measurement.

The initial trials were effectively a number of small experiments to test how LIDAR data collection performed over different types of forests and terrain and at what altitudes the best results were obtained. Results from initial trials were very encouraging; enough to convince management that it had significant potential. The only barrier being that LIDAR data collection was quite costly. It became obvious to Organisation 5 that the overall feasibility of LIDAR use was likely to be in the broader application and use of the data collected (i.e. to utilise it in other areas of forestry management beyond inventory measurement).

Stakeholders involved in the initial trial had some inclination that the data had a number of intangible benefits that would be best established by using LIDAR in an operational trial. In 2007 Organisation 5 conducted an 18-month trial across a large area operations to see how the data could support those operations and provide sustainable benefits for a full operational deployment.

At the conclusion of the operational trial the research team established that LIDAR data collection was likely to be incredibly transformative to the business. Significantly, beyond its application for inventory measurement, LIDAR had benefits for data handling and map production, resource stratification, operations planning and road location construction. Indirectly through the improved mapping data, the LIDAR data assisted the organisation to manage its conservation obligations connected to its social licence. Researchers also speculated that cost of entry barriers meant that LIDAR data collection and management was subject to scale and that services could be on-sold to smaller forestry operators that could not afford the start-up costs of LIDAR but could benefit from access to data.

Convinced by the results of the operational trial, Organisation 5 began to utilise LIDAR data collection and deploy new management systems in 2009.

Innovation activity associated with the development and deployment of LIDAR technology followed a long-term experimental process. Organisation 5 was initially unsure about the application of LIDAR for the scope of forestry management the organisation was involved with. Development started out with trial data collection where the organisation learnt how the data was structured and how it could be used. The initial stages were primarily involved with gaining access to LIDAR equipment. The LIDAR data collection process was relatively specialised task and Organisation 5 collaborated with external service providers to obtain access to aircraft with LIDAR equipment to fly and collect data. It then moved to a second phase where additional information technology was integrated into the process. Organisation 5 also acquired new information handling knowledge and capabilities through an internal research and development process.

A large portion of internal research and development process was associated with finding the most appropriate to process data so it could be used in an operational context. This involved acquiring the appropriate software and information technology platforms to manage and process large volumes of data; acquiring new data management and mapping/GIS capabilities; scripting and configuring the various software platforms; and creating new visualisation user interfaces so employees and managers could easily understand the data.

Organisation 5 appeared cognisant of the need to develop the specialised information handling capabilities to support the LIDAR data collection. Through the initial experimentation stages Organisation 5 realised that the various processes could all be modularised and that each step could potentially be sourced externally. However, it found that most of the tasks whilst requiring change, were within the grasp of the organisation to acquire over time. Organisation 5 considered commercialising the new information handling capabilities to be marketed as a service to smaller forestry operators, and ultimately a means to offset the cost of LIDAR implementation and deployment.

Organisation 5 also participated in a number of research working groups and collaborative research centres. Thus research and development and the fine-tuning of capabilities also involved significant research collaboration across industry groups and academic institutions.

As deployment progressed and new capabilities came online a number of benefits started to accrue for Organisation 5. First, there was an improvement in information/knowledge about the terrain on which the forest were grown. The improvement in data provided unprecedented precision, the knowledge was long term and had broad application across the business.

Second, the organisation gained better knowledge of forest height and structure. This benefit allowed Organisation 5 to better understand the type and volume of its assets, however ongoing data collection meant there would be improved understanding of growth rates.

There were also a number of indirect benefits. The deployments of LIDAR allowed Organisation 5 reduce its environmental risk. Unexpectedly it was also able to restructure its workforce, reducing its dependence on the tacit knowledge held by experienced staff and codifying data that had previously only been captured through experience. This reduced the risk associated with staff turnover and their ability to train new staff.

Moving forward, the cost of LIDAR technology is falling and new data collection deployment methods are emerging. For example, drones equipped with LIDAR and spaced based LIDAR.

4.6.1.2 Social structures

Innovation in Case 5 involved number internal structures within Organisation 5 and the use of external service providers to provide aerial based LIDAR data collection.

Table 4-13. Summary of actors and their roles in innovation in Case 5.

Actor	Description and role
Organisation 5	Forestry based resource management organisation and the setting for innovation.
Resource management specialists	Staff within the organisation responsible for managing the forest resources and assets.
Internal IT specialists	Internal IT infrastructure and configuration specialists.
Internal spatial information specialists	Internal IT staff with spatial and GIS mapping and modelling expertise. Responsible for building spatial models from LIDAR data and scripting GIS software.
Biometric modelling specialists	Internal scientific staff with IT skills that create information and visualisation models from the LIDAR data.
External LIDAR data collection services	Services that provide LIDAR data collection services i.e. collect LIDAR data from aerial surveys.
“Like minded” industry organisations	Other organisations with an interest in forestry based resource management and the application of LIDAR and remote sensing technologies.
Academic and research institutions	Academic and research institutions with interest in LIDAR and remote sensing technologies.
Operational staff	Staff involved in forestry management operations.

Board of management	The board of management of Organisation 5, who approve and signoff of innovation and related investments.

4.6.1.3 Information technology artefacts

Innovation in Case 5 involved the combination or assembly of complementary of information technology artefacts and assets to produce a complex architecture or systems, data and metadata.

Table 4-14. Summary of information technology artefacts involved with Case 5.

Artefact	Description
LIDAR technology	Equipment for collecting data using LIDAR signals.
GIS systems	Software platforms used to model, manage and visualise spatial information.
Database management systems	Database management system (DBMS) deployed to manage data associated with LIDAR data collection and GIS metadata.
Data models	Metadata for the description of information assets associated with LIDAR data collection.
Application server infrastructure	Backend server applications were used host the GIS and backend DBMS.
LIDAR Data	The LIDAR data assets, raw and processed data.
System architecture	The combinational design or assembly of software systems, platforms and infrastructure that allowed the systems to function as a whole.

4.6.2 Emerging themes

Following a sequence of inductive coding and analysis, thirteen themes emerged for Case 5 and were arranged into four groups of related content associated with the dual global theme of information technology enabled process innovation that evolved into an information technology enabled organisational innovation. Figure 4-5 illustrates the thematic network for Case 5.

The global theme of information technology enabled process innovation pertains to the modification and novel use of information technology to facilitate a business process innovation. The global theme of *information technology enabled organisational innovation* pertains to the implementation of new methods, practices and workplace organisation.

The themes and their groupings in the network are summarised in table 4-15.

Figure 4-5. Case 5 Thematic network

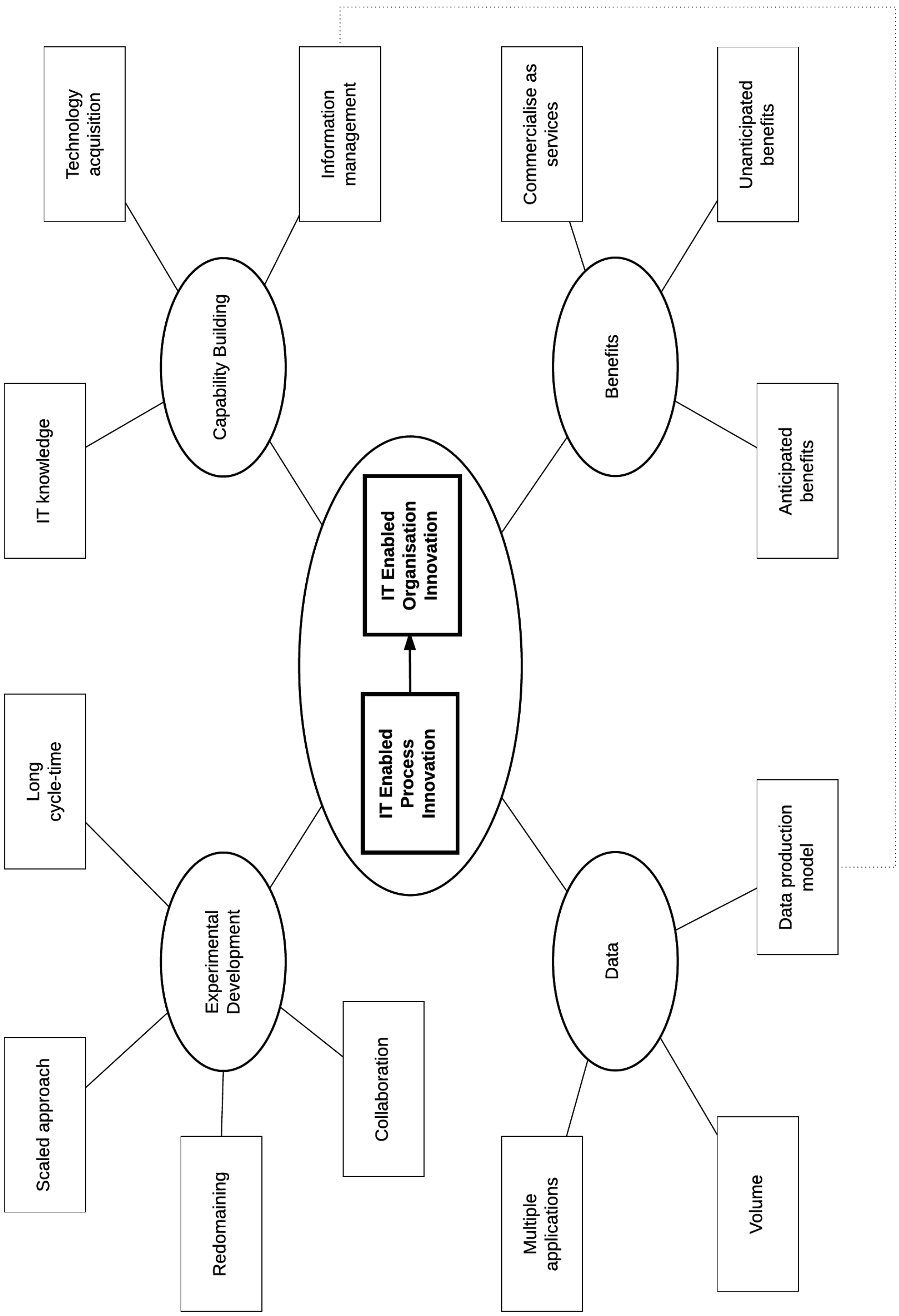


Table 4-15. Case 5 emerging themes

Organising Theme	Theme	Definition
Experimental development	Scaled approach	Development progressed with increasing scale.
	Redomaining	Technology was taken from use in another sector of the economy and repurposed or adapted for use in another. Terminology adapted from Arthur (2009).
	Collaboration	Collaboration with suppliers, competitors, academic and research institutions.
	Long cycle-time	Development spaned a long period of time.
Capability building	IT knowledge	The incorporation and application of information technology techniques and methods to engineer the system.
	Technology acquisition	Access, incorporation and integration of commercially off the shelf software, operating platforms and equipment.
	Information management	New routines were developed for information handling.
Data	Data production model	A production model or chain emerged for processing data.
	Volume	Large amounts on data were processed.
	Multiple applications	Data assets were utilised for multiple applications and purposes.
Benefits	Anticipated benefits	Benefits were realised for objectives that were planned.
	Unanticipated benefits	Benefits emerged that were not originally planned or anticipated.
	Commercialisation as services	An opportunity emerged to market capabilities as services to other organisations with similar requirements.

4.6.2.1 Dual global themes – process and organisational innovation

The notion of Case 5 having two global themes is indicative of the evolutionary process that Organisation 5 entered into when it commenced an innovation that was initially focused on process improvement. As Organisation 5 began to develop the technology for use in forestry operations it discovered that the technology and the capabilities it developed to manage and use the data was highly transformative. New routines and methods of work and workforce organisation were facilitated through the introduction of LIDAR technology (see section

4.6.2.5). Thus the second theme of organisational innovation is considered applicable to Case 5.

P5: "Where as we could have viewed it as simply replicating, replacing an earlier technology, which is the way we originally thought about this, replacing the old photo interpretation to get patches of forest. What we now realise is that a whole new approach to quantitative management is now possible."

4.6.2.2 Experimental development

LIDAR technology was seen as an emerging technology for forestry operations, but it had been in widespread use in the mining and engineering sectors. Where the mining sector was more interested in terrain profiling, forestry operators had noted that LIDAR was able to detect vegetation profiles. As a consequence, the LIDAR technology was adapted or redomained (Arthur 2009) from its application in mining and developed into a significant technology for use in forestry operations.

P5: "It tended to get used more by the engineering community and to them LIDAR was a wonderful instrument for measuring ground texture and ground terrain shape and to produce digital elevation models (DEMs). So that the engineering community used them for instance flying over a mine and so you get a wonderful 3D shape, very accurate 3D shape of an open cut mine so you could work out exactly how much you had dug out in the last month."

The development approach adopted by Organisation 5 was experimental and typically research and development focused. Innovation activity was introduced in scaled phases where the scope was initially constrained to testing LIDAR technology to see if it offered the opportunities anticipated. When the initial "experiments" demonstrated potential, a larger scale operational trial was conducted and evaluated in a highly formal manner. Meeting the objectives of the operational trial a broad scale deployment of LIDAR systems was initiated.

P5: "The reason we went into it in three steps, in what I call experimental scale which I typify as being science or technology driven small scale in terms of scale, perhaps less than representative, perhaps narrow focus and tends to be short duration and tends to be technical what can we do with this rather than is it worth it. We then went to the feasibility trial where the characteristics were representative of the business of a whole, it was of a large enough area and over a long enough time that it was quite demonstrably representative and that it was fully finically accountable in order that it could drive an investment decision and that's exactly how we designed it. On the basis of that design the outcomes it was almost QED for the board."

However the development process spanned almost a decade of activity, from initial assessment and evaluation in 2002 to 2004 through to commencing a full deployment in

2009. Thus it was arguably a very long period from the initial technology identification and selection to benefit realisation.

P5: "So in about 2002 we became aware of LIDAR as a potential way of way of measuring forest."

P5: "We got the opportunity to run a few trials down here in Tasmania across a few different sorts of forests, just some strips and so we ran a whole heap of strips in about 2004 …"

P5: "We persuaded the executive to invest in a 32,000 hectare trial in the NE of Tasmania which was to be over a reasonable period of time… So we acquired that data in about 2007 and measured what happing there for about 18 months and then wrote it up and in the middle of 2009."

P5: "We are now acquiring LIDAR over the majority of state forest and the surrounding lands … we've got stage 2 this summer coming and stage 3 in the 2011-12 year."

Whilst Organisation 5 ultimately developed new capabilities for handling the LIDAR data, it did so with extensive collaboration with a variety of external organisations. There was "arms length" collaboration with the survey organisations that flew aircraft and ultimately added the LIDAR equipment to their services. There was also extensive knowledge sharing and research collaboration with like-minded forestry organisations (along with indirect competitors). There was also research collaboration with academic and specialised research institutions. Even to the point where Organisation 5 was able to influence and establish LIDAR projects within an Australian co-operative research centre (CRC).

I0: "The collaboration aspect, you've done quite a bit your own self internally, but you actually gone off and worked with other people on various aspects as well?"

P5: "Yep. In the forest industry generally there is a certain degree of collaboration at a few different levels. There has been running over the last ten years or so a number of remote sensing symposia or conferences where those of who were interested in that hose sort of thing tended to go along and swap notes."

P5: "More recently there has been a pattern of CRCs, Cooperative Research Centres and the CRC into forestry is now on its third reincarnation. Each of those has been based in Tasmania, so [Organisation 5] has been a very active participant in those and as a result of our activity in that area we made sure that one of the programs in the most recent CRC was actually actively involved in LIDAR research."

4.6.2.3 Capability building

Innovation activity in Case 5 involved extensive new capability building on the part of Organisation 5.

New capabilities appeared to develop through three mechanisms: (1) the acquisition of new information technology platforms and equipment; (2) the acquisition of new information technology development and management skills, particularly in the areas of spatial information systems management, database management and data visualisation techniques; and (3) the development of new routines and methods for managing information and data (see section 4.6.2.4).

P5: "At one end we needed some quite intense IT technique. We needed a whole heap of GIS competence. We needed to have quite a bit of LIDAR processing skill and we needed to do quite a bit of forest maturation or what we call biometric work, which is modelling. All of those things really come together and I guess information management became a big issue as well. Plus there where a whole lot of mapping skills that had to be thrown in."

Whilst many capabilities were new it is clear from the transcripts that Organisation 5 already possessed substantial information technology and information management skills internally. This undoubtedly enabled them to source and develop the new capabilities required to integrate LIDAR data collection into their operations.

I0: "So integration into those systems you already had?"

P5: "Yes, so what would tend to happen there you might use the LIDAR data to make decisions about a stand and then you would put that stand data into the inventory systems or the asset management systems that we have written. But of themselves those inventory and asset management systems don't or didn't need to be rewritten to accommodate LIDAR. LIDAR was a way to get an intermediate data product that we hither to got a different way and so it ended up looking very similar to the previous product."

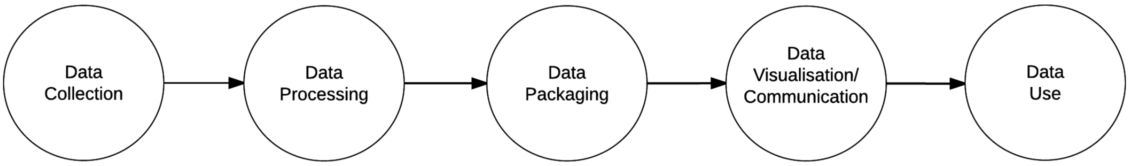
4.6.2.4 Data

Innovation in Case 5 significantly changed the way Organisation 5 used and valued its data. The sheer volume of data generated from LIDAR data collection appears to have significantly increased the volume of data it now had to manage.

P5: "So I guess for our 32,000 ha pilot study area we had about 1.2 terabytes of data, which had to be made useful. I guess LIDAR to me is the classic illustration of what I first heard from somebody years ago about remote sensing. They said, 'Trying to get useful information out of remote sensed data is trying to get a drink of water out of a fire hydrant'."

The type and volume of data also facilitated a change in the way data needed to be handled. Complex data generated from LIDAR imaging needed to collected and stored, processed and packaged to be made useful and then displayed in manner that could be understood by decision makers and operational staff.

Figure 4-6. Case 5 data production chain



P5: "I guess that's been one of the big secretes of the pilot project for us, actually making the data digestible. What we ended up doing there was to turn it into a series of standard map products or map layers if you like, each of which could be viewed individually and analysed individually, but could also be analysed in conjunction with each other and other products again."

Organisation 5 also found that it was able to use the LIDAR data for multiple purposes and applications. In some cases it was even able to utilise the same data packages for multiple functions. In conjunction with the systems it was using, data had become a platform for process and organisational innovation.

P5: "Whereas the LIDAR approach what we have realised is that you use the one model to do all three jobs. The one set of low intensity calibration plots do the lot and you can apply what amounts to strategic level estimates for operational level problems and that's of course where a lot of our savings is going to come from and totally change the way we look at forest measurement. We don't now have to do it in three different bites."

4.6.2.5 Benefits

Organisation 5 set itself clear objectives through each phase of innovation activity. These objectives sort to demonstrate or identify the anticipated operational benefits could be obtained with broader technology deployment. Furthermore experiments were designed to establish a formal business case for full deployment. Where costs exceeded benefits, activity was designed to establish if additional benefits could be obtained.

The initial experimental development activity was successful in demonstrating anticipated benefits associated with LIDARs application to forest inventory management. It was also successful in demonstrating further anticipated benefits in data handling for map production, coupe planning, harvest planning, road construction, and environmental/conservation compliance.

P5: “That data was well and truly enough to convince us that we were on to something very powerful.”

P5: So they then realised once they started to get that sort of information they realised they could get more and they have started heading down that way and I guess other people are reacting to the sort of paper that we’ve of put out and our approach which is very much more holistic and realising if they point Lidar at a whole lot more problems it becomes a whole lot more profitable to do and that’s I think the big breakthrough for us.”

Experimental work also anticipated the opportunity related benefits of commercialising the information management capabilities Organisation 5 would need to develop as part of the LIDAR deployment.

P5: “So one of the potential ways for us to make LIDAR processing pay was for us to offer a service to surrounding landowners and forest managers and that’s precisely what we have chosen to do. And so a number of the Tasmanian forestry companies who are smaller than we are and who haven’t got those same ranges of expertise and IT infrastructure have realised that it’s much more cost effective for us to that for them and of course the more we can bulk up the more economies of scale we build into our own system.”

After the operational trials Organisation 5 started to find unexpected benefits in the way the new capabilities were able to change workforce knowledge management practices, and reduce the organisation’s dependence on difficult to obtain and develop forest management skills. The organisation also found that that the newly developed data assets had a broader than expected application across forest management practice.

P5: “The other really interesting one, which we hadn’t anticipated, was our vulnerability to staff loss. One of the things we found is that the new mapping products and the information they brought with them meant that it was much much easier for our ground planners to do the job and that the quality of the planning job was better and the ease at which it was done was better and that those two things accrued to both our experienced and inexperienced staff. One of the problems in an environment where you have increasing turnover of staff is that you lose experience in an absolute sense. You lose people before they get too much experience and secondly you lose knowledge of that local area and both of those are very big issues for this particular problem and what we have realised is that LIDAR will make the job of ground planning very much less dependent on staff [experience] …”

4.7 Case 6 – Healthcare medication management software

4.7.1 Context

Case 6 investigates the development of a medication management software system, its evolution from early concept through to commercial success, and onward to a comprehensive e-health decision support solution. Case 6 differentiates itself from other cases in this research because it focuses not so much on the innovation activity associated development of the information technology, but more upon the evolution of a commercial enterprise that was built up from a single information technology innovation.

Organisation 6 is a small e-health software business that provides clinical information systems focused on medication management and clinical communications. Organisation 6 was established in 2005 by means of business grant to assist in the commercialisation of software that was developed to support clinical pharmacy practice in hospitals. The organisation comprised a three-way joint venture between “the founder” (a practising clinical pharmacist), a software development company and a business incubator.

The software developer provided commercial software development expertise. The founder whilst familiar with software development did not have expertise in the development of commercial solutions that used commercial development platforms. The software developer also provided access to a web based software development platform or framework that allowed initial versions of the software to quickly take shape.

The business incubator provided specialised in assisting new businesses with finance, governance and marketing resources. Again capabilities the founder acknowledged that he was not experienced with.

Within the hospital pharmacy context there are two prominent roles involving pharmacists: (1) dispensing medicines and (2) clinical pharmacy. Whilst dispensing medicine is self explanatory, the clinical pharmacy roles involves providing advice to health practitioners in relation to the most appropriate medicines for a patients’ condition, how to administer medicines, and providing advice directly to patients about how to take their medications. From as software perspective, most pharmacy software was focused on the dispensing role. However, as many as three times the number of pharmacists were involved in clinical pharmacy than were in the dispensing role. The founder of Organisation 6 began to realise this opportunity and commenced a pathway towards the development of software to support clinical pharmacy practice.

Innovation activity in Case 6 arguably spanned a long period of “pre-establishment” where the founder was involved in clinical medication management practice within the public health sector. Task or problem oriented software was developed using end-user development tools that unintentionally became prototypes for future developments. Once Organisation 6 was established, software design and development appears to have progressed in a traditional sense following relatively formal incremental design, build and test sequences. The requirements developed from the experiences of the founder and coded by professional developers using commercial development tools. The software was then marketed to the health sector and successfully established in several hospitals.

Organisation 6's pathway to commercialisation was not a straightforward process:

- Intellectual property rights – commercialisation was initially hindered by arguments concerning the intellectual property associated with founder's original software developments in the public health sector. The issues were resolved with a formal agreement, but at the cost of considerable time and effort.
- Knowing what to develop – as development advanced from the original prototype Organisation 6 came to the realisation that it had progressed the software development in the wrong direction. The original software design was oriented towards the processes within hospital clinical pharmacy practice, however it was resolved that it should have been designed from patient centric perspective.
- Issues marketing to the health sector – the health sector was seen as reluctant investors in information technology where there were significant gaps between decision makers in information technology departments and the clinical users of information technology solutions.

Arguably Organisation 6 has been successful in initially developing a commercial solution that supports clinical pharmacy practice. It has also taken that initial product and developed several complementary products to build a platform that deals with medication management, medication knowledge management, electronic referrals, and integration of patient diagnostic information from other health applications.

4.7.1.1 Social structures

Innovation in Case 6 involved a three-way joint venture between "the founder" (a practising clinical pharmacist), a software development company, and a business incubator. The innovation also emerged from a phase of pre-commercialisation that involved interaction with a clinical pharmacy practice in a public hospital.

Table 4-16. Summary of actors and their roles in innovation in Case 6.

Actor	**Description and role**
Organisation 6	E-health software business and setting for innovation in Case 6.
Business owner/founder	Business owner of Organisation 6 who conceived and progressed the development of the innovation in Case 6. Initially conduced end-user software development that formed the starting point of the innovation in Case 6.
Hospital clinical pharmacy practices	Hospital based pharmacy practices that were responsible for medicine management in hospitals.
Software development business	Provided software development expertise and skills used in the development of software. Provided access to a web based software development platform or framework facilitate initial development.
Incubator business	Provided finance, governance and marketing resources for Organisation 6
Clinical pharmacists	Providing advice to health practitioners in relation to the most appropriate medicines for a patients condition, how to administer medicines and providing advice directly to patients about how to take their medications.
Public health sector	The public or government owned and operated health sector

4.7.1.2 Information technology artefacts

Innovation in Case 6 involved the development of healthcare medication management software and the evolution a commercial enterprise providing e-health decision support solutions.

Table 4-17. Summary of information technology artefacts involved with Case 6.

Artefact	**Description**
Medication management software	Medication and decision support software.
Software development framework	A framework of libraries and scripts that was used to facilitate a quick initial software product.
Prototype software	Software that was initially developed by the founder that unintentionally became the initial prototype for innovation.
Intellectual property	The software design and code and subject of a rights dispute.

4.7.2 Emerging themes

Following a sequence of inductive coding and analysis, 10 themes emerged for Case 6 and were arranged into two groups of related content associated with the single global theme of information technology enabled product innovation.

The global theme of *information technology product innovation* pertains to the development and successful use of a novel information technology solution within the organisation. The themes and their groupings in the network are summarised in table 4-18 below and figure 4-7 illustrates the thematic network for Case 6.

Figure 4-7. Case 6 Thematic network

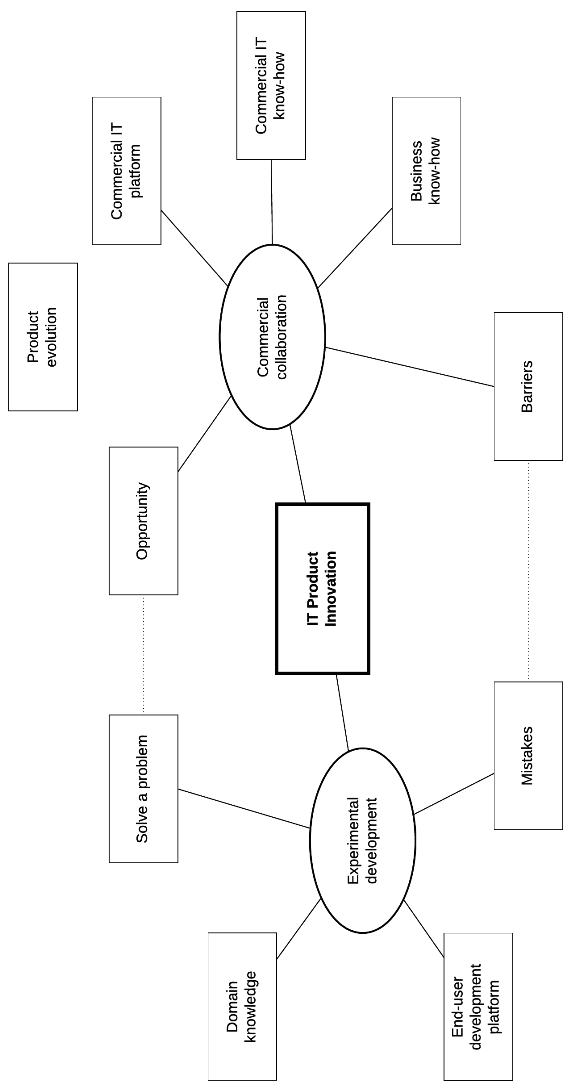


Table 4-18. Case 6 emerging themes

Organising Theme	Theme	Definition
Experimental development	Domain Knowledge	Knowledge of the domain of application and use.
	Solve a problem	Development activity was concerned with solving a problem (associated with the collection, storage, processing and distribution of information).
	End-user development platform	An end-user software development tool was used to progress development.
	Mistakes	Mistakes were made in the design and development.
Commercial collaboration	Opportunity	A commercial opportunity was identified.
	Commercial IT know-how	External professional information technology development knowledge was sourced/utilised.
	Commercial IT platform	An external and commercial IT development platform or framework was utilised.
	Business know-how	External business administration skills were sourced/utilised.
	Barriers	Barriers preventing innovation progress and commercialisation were experienced.
	Product evolution	The product (portfolio) evolved and added more features and functions.

4.7.2.1 Experimental development

The innovation in Case 6 occurred over a long period time, commencing well before the formation of Organisation 6.

An essential component of the innovation throughout its lifecycle was the domain knowledge the founder of Organisation 6 had gained through his experience as a clinical pharmacist working in the public health sector.

P6: "Having a trained background as a pharmacist, spending ten years working in hospitals both in Australia and overseas, was my area of work was clinical pharmacy."

P6: "Obviously I had the main knowledge and understanding of the field and what the business had to deliver around medication management software."

This experience allowed the founder to identify and attempt to solve the problem of information management for clinical pharmacists.

P6: "We need to be able to document when issues arise around medicines … We need to provide counselling sheets for patients so that they know how to take their medicines when they leave hospital."

At a latter phase of the experimentation and during the formation of Organisation 6, a major mistake was identified or realised within the design. The mistake was arguably a product of the initial organisational context and saw the software incorrectly focused on routines or processes used in the hospital pharmacy setting when it needed to focus on the patient's care and associated processes.

P6: "Totally, because it was wrong. It was wrong because it was looking at business practice as a process base rather than patent centric. The concept when I was with the agency was the wrong way to go, so second time. You build it wrong to get it right."

4.7.2.2 Commercial collaboration

Commercialisation of the innovation in Case 6 was a collaborative initiative involving a joint venture between the founder, a software development business and an incubator organisation. Representatives from the three stakeholders effectively formed Organisation 6.

In effect developing the prototype software in the hospital setting allowed the founder to identify that there was a commercial opportunity to develop software to meet the needs of clinical pharmacy in hospitals.

P6: "So all of those things came to the point of me realising that while three times as many pharmacists where out on wards doing clinical pharmacy as were dispensing and while there were dispensing software applications in every hospital and community pharmacy around the country there was no software available for this substantial number of clinical pharmacists roaming the wards. There were some overseas applications that had been developed. Every hospital in Australia has somebody who had done (developed) a little database here and a little spreadsheet there, as I was doing. But the concept of drawing it all together into an enterprise level software application was not addressed anywhere and so that became the seed for the business."

Organisation 6 was also partly funded by way of an innovation grant to assist in the commercialisation of the software. This grant also appears to have facilitated the introduction to the incubator partner that specialised in providing business administration and marketing resources.

P6: "I had no knowledge of business therefore [incubator] being involved for providing the framework for running a business, which means board, business advisor, accountant, bookkeeper, etc set a framework where I could actually have some structure around the generic aspects of a small business."

To progress a commercial product it was necessary to source professional software development skills to develop software that was suitable for large-scale deployment.

P6: "The third partner [organisation] with [partner] bought in the IT component, because I was under no delusion that having fiddled around in MS Access would allow me to direct the creation of enterprise level software."

In sourcing the development expertise Organisation 6 was also able to obtain access to a commercial software development platform that assisted with the fast and cost effective development of commercial software.

P6: "They had an existing web platform, which they had been building solutions with and they offered that up to the company for building a medication management solution on as well."

The founder of Organisation 6 also acknowledged that he had limited experience managing and marketing a commercial business and availed use of skills and resources provided by the incubator partner.

As elaborated in section 4.7.1 a number of barriers were encountered during the commercialisation process – arguments about intellectual property rights with the founder's previous employer; mistakes in the original software design and difficulty marketing software to the health sector.

Once the core product had been developed Organisation 6 began to add (evolve) new related products to its software portfolio, covering off on processes linked to patient care and the use of pharmaceuticals.

P6: "That's part of the enterprise level software development I alluded to before. I talked before about acute and primary settings becoming blurred in the future, if you don't have an application that can handle that multi-site, multi-client type capacity where are you going to sit, how are you going to contribute to that unified health record."

4.8 Case 7 – Interactive multimedia in community health

4.8.1 Context

Case 7 investigates the development and deployment of an interactive multimedia platform used to facilitate health literacy in remote disadvantaged indigenous populations throughout Australia. It follows an initial phase of information technology innovation and the emergence of a social business enterprise (Organisation 7), founded upon the successful digitisation of educational content and its distribution via a network of touchscreen kiosk installations.

Organisation 7 was ultimately established from a research project in Northern Queensland, Australia in 2001 that was setup to evaluate the use of touchscreen kiosks for health education in an indigenous community.

The project was characterised by the use of participatory development practices where content was co-created with the target community and the digitised for playback on a touchscreen kiosk. The co-creation or participatory development method had previously been utilised by researchers as a technique for communicating sensitive social and health issues in remote indigenous communities. One of the founding researchers had previously found the use of "forum theatre" to be very effective but difficult to administer and sustain.

During the initial research phase researchers set out to establish the viability and user acceptance (attitudes and intentions) of an indigenous community to use interactive multi-media content on a kiosk like touchscreen device. The project partnered with an overseas firm to provide kiosk equipment and publishing software. Researchers then engaged with the target community to identify a suitable health issue to digitise and deploy via an interactive touchscreen kiosk. The software and equipment at the time was fairly limited by current standards. Media was constrained to graphical pictures, audio and basic navigation elements. Appropriate content was sourced and picture book style content was developed with audio voiceovers created by the community. Additional content was developed and deployed in conjunction with the community.

The initial phase was deemed a success and progress commenced on second three-year phase that would explore the health and technology-related outcomes from the kiosk use. These outcomes were to be measured in terms of changes in knowledge, attitudes, behaviour and local capacity. The second phase also looked at how to implement a sustainable IT-based approach. As a consequence kiosk equipment and new software capabilities were sourced from a local (Australian) supplier. The ability to incorporate video and other capabilities into the interactive digital content was also given priority based on feedback that had suggested users wanted more control of the content playback.

During phase 2 the project added three more participant communities and engaged with a Sydney based supplier for the kiosks and content management software. The new supplier developed a platform to managed the content called the Module Editor, along with various subsystems to managed content distribution, usage reporting, and kiosk device management. The project team then set about creating more content in conjunction with the two participating communities.

Towards the end of the second phase an opportunity emerged to expand the network of communities participating in the program. Organisational arrangements for the project also changed with a number of universities and health organisations collaborating on the project. The project quickly grew to include eleven kiosks with significant geographical (national) reach. The project also started to explore web based delivery options for its kiosk platform.

As the project was established as a research program the outcomes were rigorously evaluated. The project was essentially a social experiment involving information technology acceptance, adoption and use within a social context. Outcomes from the project at the end of the three-year phase were mixed or unclear. At the community level the project had been unable to demonstrate any health literacy or behavioural changes. At the service delivery level the project had also struggled to gain diffusion into clinical protocols or activities, despite acknowledgment from partitioners of the health promotion relevance of the content distributed through the kiosks (Hunter, Travers & Gibson 2007).

During phases two and three the project was beset by several problems.

First, there was a range of problems with the development of the new software platform. The initial release of the software had a number of quality issues (faults). The developer was relatively inexperienced in this area of development and the project team, in the quest for innovation, pushed the scope along, surrendering any notion of a planned or structured approach to release, testing and operations.

The developer and project team also underestimated the limitation of network access and availability and its impact for operations and ongoing management of the kiosk system.

To resolve these issues the project team employed a technical manager to address the problems. The technical manager brought a high degree of structure into the development and operations processes. Formal requirements planning, adequate testing and operational tracking of faults were introduced and the project started to overcome a number of its technical problems, or at least have workarounds put in place.

Despite the issues faced by the project, at the end of phase 3 there was a perception that under the right conditions of – appropriate technology design and deployment, maintenance of the participative development methodology for content creation, and the diffusion of health promotion into clinical practise, that the use of interactive multimedia technology was a viable ongoing mechanism to deliver better health outcomes in remote disadvantaged indigenous communities.

Organisation 7 continued to evolve and develop the touch screen kiosk network. Funding had become more difficult. This limited Organisation 7's ability to make significant changes, but it was able to keep the existing network operational and still had a plan and vision to grow the network.

Issues remained with the original software platform. As Organisation 7 was looking at new ideas to replace the software platform, the supplier of the software and the kiosks went into insolvency. As a consequence of this event Organisation 7 obtained access to the source code for the content management software and established a new partnership with a more advanced supplier of touch screen kiosks. The development of multimedia technologies and platforms had also advanced significantly since the first inception of the Module Editor software. The content creation industry had largely adopted Flash and the related family of interactive multimedia authoring tools from Adobe. Organisation 7 created a new hybrid solution that allowed them to maintain their existing systems, whilst incorporating Adobe Flash based content into their content modules.

Organisation 7 was then able to incorporate a range of successful additions to its content portfolio. It also progressed quickly with a web based virtual kiosk, the development of applications and extremely successful experimental efforts with social media.

The process of experimental development and the ongoing opportunity to solve health information based issues in disadvantaged communities using interactive multimedia systems also facilitated the emergence a relatively unique organisation. This organisation had a social enterprise focus based on collaborative community and industry partnerships and the use of information technology.

In 2011 Organisation 7 transitioned to a university sector incubator in Brisbane with the objective of forming an independent social business enterprise. In 2013, the organisation had successfully made this transition focusing on the production of "rich learning media with and for those living on the wrong side of the digital divide – populations marginalised by culture, technology, socio-economic disadvantage and distance". Organisation 7's national network of touchscreen kiosks in combination with its content management platform being an essential enabler of that mission.

4.8.1.1 Social structures

Innovation in Case 7 involved development of the deployment multimedia kiosks and the creation of multimedia content collaboration users in remote disadvantaged indigenous populations.

Table 4-19. Summary of actors and their roles in innovation in Case 7.

Actor	**Description and role**
Organisation 7	Organisation 7 was an e-health social business enterprise and the organisation that facilitated innovation in Case 4.
Organisation 7 founders	Two individuals that founded the initial projects and formed Organisation 7, also referred to as the project team.
Organisation 7 technical manager	Organisation 7 staff member recruited to provide advice on the information technology components and assist with managing the project/program.
Remote indigenous populations	The customer and participants in the original research program. Users of the kiosks, consumers and co-creators of the content.
Research program	The initial phase of research from which Organisation 7 and the innovation emerged.
Academic institutions	Universities involved at various stages of the research and commercialisation process.
Healthcare organisations	Organisations charged with the delivery of healthcare to remote indigenous populations.
Health practitioners	Healthcare practitioners working in remote indigenous populations.
Multimedia developers	Specialist suppliers of multimedia production services.
Kiosk/IT Partners	The supplier of kiosks and content management systems, there were three through the life cycle of innovation.
Incubator	A University lead incubator that facilitated the commercialisation and transition to social business enterprise.

4.8.1.2 Information technology artefacts

Innovation in Case 7 involved the deployment multimedia kiosks and implementation of content management software and the distribution of digital multimedia content.

Table 4-20. Summary of information technology artefacts involved with Case 7.

Artefact	Description
Content management system	A software system to organise and manage digital content, particularly in terms of sequencing and orchestrating the content navigation and flow.
Kiosks	Hardware to host and playback the multimedia content.
Virtual kiosks	A web based version of the kiosk multimedia player.
Networks	Broadband networks, particularly in the context of their lack of availability or the potential opportunity of their availability.
Computing Infrastructure	Server based infrastructure to run back office applications and utilities in support of the content management software and kiosks.
Digital multimedia content	Combinations of digital text, sound, graphics and video organised in to packages or modules for distribution to kiosks.
Mobile applications	Mobile base applications in support of the objectives of Organisation 7's health education and promotion objectives.
Social media	The use of social media in support of the objectives of Organisation 7's health education and promotion objectives.
System architecture	The combinational design or assembly of software, content and infrastructure that allowed the systems to function as a whole.

4.8.2 Emerging themes

Following a sequence of inductive coding and analysis, fourteen themes emerged for Case 7 and were arranged into four groups of related content associated with the dual global theme of information technology enabled process innovation that evolved into an information technology enabled organisational innovation. Figure 4-8 illustrates the thematic network for Case 7.

The global theme of information technology enabled process innovation pertains to the modification and novel use of information technology to facilitate a business process innovation i.e. the development and distribution of interactive multimedia content. The global theme of *information technology enabled organisational innovation* pertains to the implementation of a new organisational form for what was initially an organisation based on a single project.

The themes and their groupings in the network are summarised in table 4-21.

Figure 4-8. Case 7 Thematic network

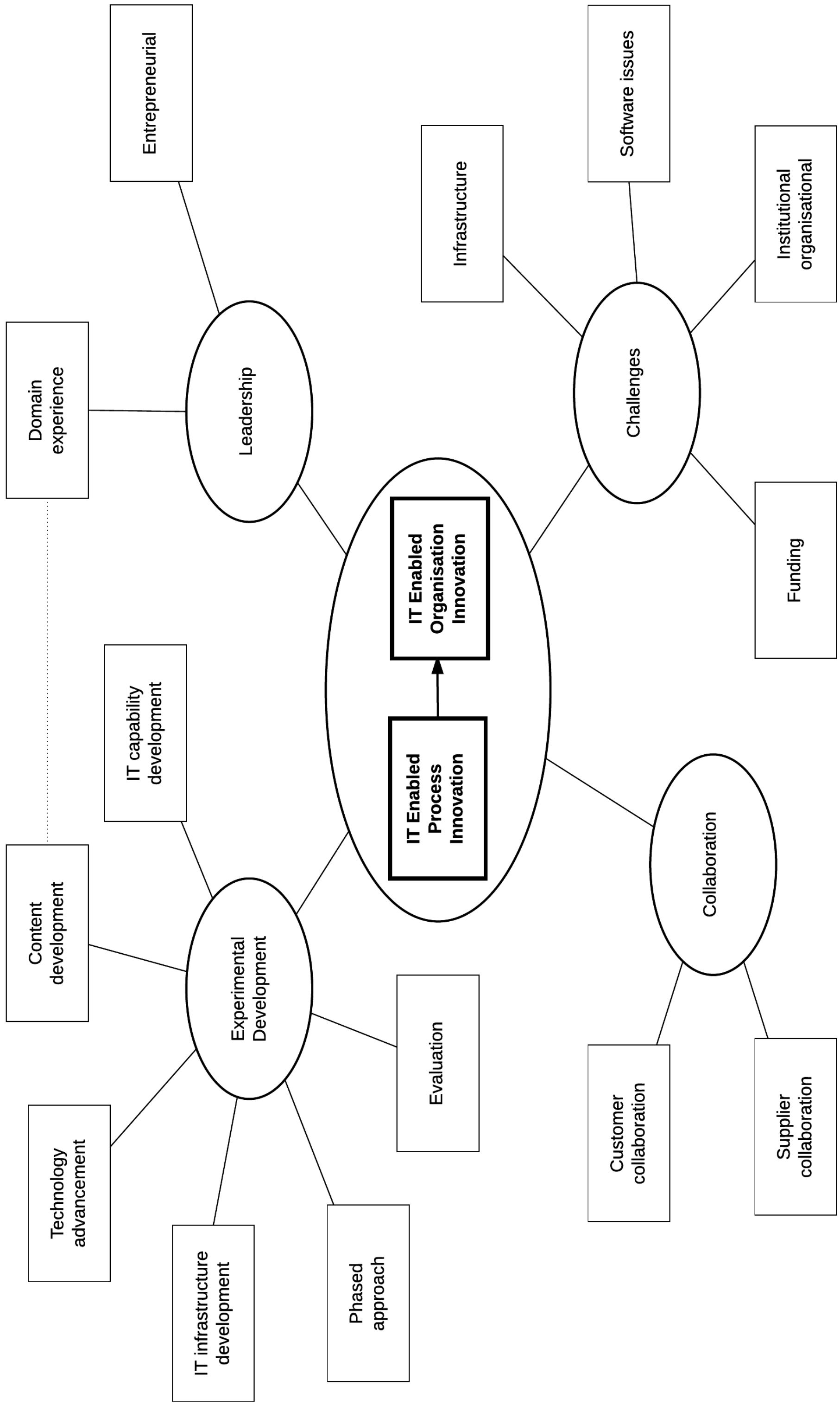


Table 4-21. Case 7 emerging themes

Organising Theme	Theme	Definition
Leadership	Entrepreneurial	Leadership taking the initiative for innovation and assuming the risk.
	Domain experience	The application of experience in the health education and promotion field.
Experimental development	Phased approach	Distinct stages or phases associated with experimental applied research and development.
	Content development	The development of digital/multimedia content, distinct from software engineering.
	IT infrastructure development	The development of IT infrastructure, software platforms and kiosk equipment.
	IT capability development	The development of IT capabilities to manage development and operational processes involving IT design and use.
	Evaluation	Formal evaluation processes for the project outcomes.
Collaboration	Customer collaboration	Interaction with customers/users for development activities.
	Supplier collaboration	Interaction with suppliers for development activities.
Challenges	Funding	Obtaining the funds to operate the initiative and expending those funds.
	Infrastructure	Access and availability of IT infrastructure and infrastructure-based services.
	Software Issues	Problems with software development, reliability and quality (fitness for purpose).
	Institutional organisational	Issues operating under the institutional and organisational structure and transitioning into workable structures.

4.8.2.1 Dual global themes – process and organisational innovation

Two global themes were identified for Case 7. There is evidence initially of information technology enabled process innovation in terms activity to develop and assembled information technology capabilities and infrastructure and used them to facilitate the digitisation and deployment of health education content in the form of interactive multimedia modules. However over time the information technology process innovation enabled a new form of organisation for Organisation 7. Transitioning it from a university based research program to an independent social business enterprise, a new organisational form. Section 4.8.2.5 describes the process in more detail.

4.8.2.2 Leadership

The creative leadership of the founding researchers drove innovation in Case 7. Both researchers demonstrated an entrepreneurial leadership and a commitment to innovation in order to archive the objectives of the initial program.

P7.1: "In the beginning we a company that kept the constraints and the reins in so tight that we went allowed to fall over and make any mistakes and we were very safe, but it was a very boring and uncreative experience for the users and we wanted to be able to make our own mistakes. To be more creative in our approach, to what we provided to end-users. We ended up experiencing many, many problems in that three years, of course. But we kept innovating every time we produced a new module a new module we improved and added new elements."

P7.1: "I think that some of the biggest barrier has been around innovation and in fact I have come up with a new motto for our project in response to that and that is "proceed until apprehended."

The same leadership also prevailed in recognising problems that needed to be solved throughout the program's development. This included the need to transform the program into a social business enterprise.

P7.1: "We hope to be sitting in that incubator for two years and at the end of that two years be a fully fledged social enterprise, with all our IP, all our business, all our everything sorted out and ready to fly and leave the nest."

Leadership in Case 5 also had significant experience dealing with indigenous health issues, health promotion and education. This experience was successfully applied to the digital sphere, taking key learning's from the participatory model that had been developed using forum theatre in similar contexts.

P7.1: "So one of the things I did was to establish the theatre troop that would practice forum theatre and go to the remote community and work with them. The theatre troop idea was great, it was effective but it was a really, really hard thing to administer and sustain … But I didn't ever forget it impact and how effective it was and little did I know … that I would have the opportunity to use that theatre experience and forum theatre in particular in a way that was sustainable and that was working with real grass roots people out there on the ground to create the learning materials."

4.8.2.3 Experimental Development

Having originated in the university sector, the development in Case 5 was distinctly research driven and experimental in design. The development initially was split into two distinct phases, then later three with varying levels of design to meet high-level program objectives.

Development was centred upon three different types of activity. In the initial phase development focused on the development of IT infrastructure and the creation of digital content. IT infrastructure development was initially concerned with the acquisition of hardware and software to operate the kiosk but in later stages this extended to having a third party design and develop a customised hardware and software platform to manage and deploy interactive multimedia content.

P7.1: “we recommended that an Australian software provider be sort and then engaged. In fact we wanted integrated provision because these are such remote places that if things go wrong with the technology then its difficult to solve the problem. We didn’t want some little place having maybe a problem with the software and the software company and that and maybe it was the hardware and one blaming the other and you know.”

The development of digital content was pervasive through the entire lifecycle of the innovation. In the initial phases content creation was constrained by software and hardware limitations, however modifications to the content management software and eventually the adoption of the Adobe software platforms improved the scope of possibilities for content creation.

P7.2: “We were going to some of the Adobe refresh seminars and things because we were heavily flash based and we identified at that stage that our content developers wanted to use standard industry tools, rather than our clunky module editor, to develop content. So the standard industry tools in those days, I think its still the case was Adobe CS5 creative suite. So really we were looking at creating a kiosk platform that would interact with the Adobe products. We ended up choosing a company in Sydney who specialise in Adobe products and Adobe development and so on.”

During the early stages of development Organisation 7 have very limited IT capabilities. As innovation activity progressed the organisation incrementally increased its IT capabilities. During phase 2, facing a range of technical issues Organisation 7 added a technical manager who set about improving the organisation’s IT requirements planning, testing and IT operational capabilities. Organisation 7 then continued to develop new IT capabilities in conjunction with its suppliers.

P7.2: “I setup some systems and processes and things because we no sort of logs of what we had out there and what content was where and as the network quickly grew, which it did in the first couple of years, you know just sort of maintaining logs of what hardware we had where and version control, software and content and so on because nothing like that had been setup yet.”

Changes and advances in information technologies also influenced the development process. Initially platforms for managing and creating multimedia content for kiosks were not prevalent or standardised. However the program progressed through a decade and during that decade there were major advancements in software technology and video encapsulation techniques that then influence decisions for software platform acquisition and development.

P7.1: "Two things that drive innovation really are on the one hand, the community users themselves and the responses that we are getting from them and the ideas. Then on the other hand its this world of technology that's moving so quickly. So we are on the lookout for what's happening and wanting to remain at the cutting edge of that."

Organisation 7 was also contractually and institutionally bound to provide formal evaluation of its research outcomes. Comprehensive evaluation of the health and research outcomes was conducted examining and reflecting upon the challenges faced by the program and the potential solutions for operations to move forward.

P7.1: "The first year long study was very much participatory reaction research and that was a really useful way to go. I spent a lot of time in the two communities where it was being trialled. Evaluating its impact and any process evaluation as well, because people from those two communities were very active in the production of these early modules."

4.8.2.4 Collaboration

There was a high degree of interaction and collaboration undertaken between users or community stakeholders (customers) and the development teams in relation to the digital content. Participation of the constituent communities in the development of context-oriented content was a deliberate implementation strategy put forward by the research team. By creating content that was relevant and familiar to potential users it was thought that attitudes towards use and general acceptance of the kiosks as a delivery mechanism would be successful. As it turned out content generated in other communities who had potentially similar backgrounds but were in different locations also accepted content generated in this way.

P7.1: "We worked with the local community in Cairns to do the voice overs and things like that and to do the artwork and put it out there, it was well used and well received."

P7.1: "Exactly, so what we find is that contrary what everybody in health promotion told you once, there is great curiosity about one another and about different places etc, also very shared issues, health and social issues. A lot in common, but then just fascinating differences, so then what we find, because we get our data from the kiosks to illustrate how well they are or aren't being used, is that people in central Australia for example, the modules that seem to use at the most are the ones that were filmed on the NE coast of Cape York. That's about turtle hunting and all sorts of different things. So this desert mob just love it."

There was also a high degree of supplier collaboration in the development of IT infrastructure. Organisation 7 had sourced the expertise for kiosk and content management system development from external parties throughout the development lifecycle. This collaboration was possibly on marginally successful in meeting the desired outcomes for IT infrastructure (see 4.8.2.5) until the most recent partnership that seems to have delivered stable and sustainable infrastructure.

P7.1: "They in fact produced for us something that we called the Module Editor and so it was an online content production system, content management system and it was pretty audacious stuff back in those days, there was certainly nothing else like it."

P7.2 "We ended up choosing a company in Sydney who specialise in Adobe products and Adobe development and so on."

4.8.2.5 Challenges

Overall the program faced considerable challenges and arguably, at least at an empirical level it failed to satisfactorily provide improvements in health outcomes or behaviours in the remote indigenous communities where it was initially implemented. Although the program did provide sufficient research on how those issues may be solved, thus we find the successful ongoing deployment and use of the kiosk systems.

There were four major challenges described in the interview transcripts and evaluation reports – (1) funding, (2) software problems, (3) access to communications infrastructure and (3) institutional and organisational issues.

Funding issues appeared to be ever present in the evolution the innovation in Case 5. Organisation 7 was perennially dependent on receiving grants and government funding in order to operate. At one stage the organisation reached a critical funding crisis and this appears to have been a key event in Organisation 7 lifecycle and the ongoing sustainability of the innovation. The crisis reoriented Organisation 7 to look at revenue models for sustained operation.

P7.1: "As service providers when we hit a funding crisis in 2008, which really was a crisis, we had been expecting 3 years funding to continue at that stage from the commonwealth and didn't find out 2 weeks before the end of financial year that not only would we not be getting the extra funding we had hoped to be receiving, we weren't getting any funding. So no operational funding at all and we were totally dependent on government grants at that stage. In response to that crisis a lot of things happened but one of them was that we began to operate in a cost recovery mode and the University allowed us to do that. We never imagined that we

> could receive revenue. So that was really, a light went on. We can began to play with pricing and realised pretty quickly that it's a good idea to make profit."

Software issues also challenged the ongoing sustainability of content publishing and delivery. In the initial instance the selected software platform was too limited and constrained content development to picture book style modules which lacked the level of interaction and rich media interaction that was required to be attractive to users. Seeking improvements in the level of interaction and the ability to manage content on the kiosks a content management software platform was developed to work with the kiosk hardware. Whist this software was an improvement in capability it contained many faults. So much so that Organisation 7 hired a technical manager to bring some structure and understanding on how best to improve or workaround the issues.

> P7.2: "Two years ago it got to the point where we were sick of the module editor and the content developers were sick of using it and they were complaining about bugs and by that stage it was the end of 2007 that the software/hardware provider said that they can no longer support or have anything to do with our software because it no longer fitted with their business model."

Linked to the software issues were additional problems with gaining access to reliable communications infrastructure and services to sites where the kiosks were installed. The software had been designed so that content could be managed remotely; it had also been design to provide access to usage logs using remote communications. These issues made it difficult to operate and maintain content on the kiosks.

> P7.2: "At that stage we had four of the kiosks at the same company, four of their kiosks in remote Cape York sites. They were just sitting their with no content on them and not even networked, so that implementation/installation had been not very well thought through. Then it was up to us with hard drives out there with the content on them trying to go about getting them network and so on."

Infrastructure was also a general community issue, with access to computers in homes not very prevalent in the participating communities

> P7.1: "Lots of people don't have smartphones yet but I really believe that you know people out there are never going to have that computer in their house, with all of the wires and complicated and all the support you going to need to keep the computer running. They are going to have mobile wireless and they are going to have mobile internet, in whatever form. So they will just skip that whole computer business, I reckon."

The institutional and organisational issues were present in two quite different areas. The first related to the institutional arrangements for clinical health providers working in the indigenous communities. These practitioners accepted and understood the value of health education and promotion, they also appear to have accepted the value of delivery via the kiosks, however because health education and promotion was not a priority in the clinical protocols, practitioners were not sustained in their participation in the program. The second area of institutional and organisational challenge was getting the program to work in the institutional environment of a university. Whilst the university provided human resources and other administrative support, it was not particularly flexible enough to support some of the ad hoc business relationships that were required to operate in an innovative manner in conjunction with remote indigenous communities. These issues were a major driver for transitioning the organisation to an independent social business enterprise.

P7.1: "One of the barriers was trying to work inside a university environment and do grass roots production work. It was just that kind or thing like "I'm sorry we can't be paying people who don't have ABNs and we can be doing this and no I'm sorry you cant pay for catering that way and no we cant provide cash. We were trying to generate work and business in every single community production we undertake and so we want to pay every community person award wages as an actor, we want all our catering to be in the community, all our transport, etc. Accommodation, what ever we claim, how can you stimulate in those places. So a university didn't give a rat's arse basically about that kind of thing."

P7.1: "We have done a lot of work in response to the serious constraint and not seeing a future for this work. Mind you if the work is good and the work is working then you have to, you cant stay in the university forever anyway, you have got to stand on your own two feet. …The innovation in business space sees us moving towards a social enterprise in our own right. We are transitioning from creative industries precinct in Brisbane for a two year period we hope and we call that an incubator."

4.9 Case 8 – Virtual printer software commercialisation

4.9.1 Context

Case 8 follows the development and commercialisation of a document routing system that allows the output of standard print jobs to be directed to common document distribution technologies such as email, facsimile, SMS, or digital archives. The software was initially developed and sold as Shareware by a software engineer based in the Netherlands (Organisation 8a), but was taken to a new level via a joint venture with an established systems integration business operating in South Australian, Tasmania, Victoria, and Western Australia (Organisation 8b).

Data collection in Case 8 is focused on the experience of the systems integrator (Organisation 8b), and its role facilitating quality improvement and broader diffusion as a commercially successful document routing system.

Around 2001 Organisation 8a had developed an innovative document routing print driver that recognised and extracted coloured text in a print stream. It then used the coloured text to route the printed document as an attachment for email or facsimile. Organisation 8a was selling this software online as Shareware. One of the benefits of this software was that it could be integrated and used with any software that allowed the user to design and customise reports (as long as it supported colour output).

Around the same time, Organisation 8b was migrating a number of its clients from a small business accounting package to a mid-tier financial system. It had struck a problem with the users of the smaller package in that the software provided a relatively unique document routing system for invoice and statements that allowed the user to batch send documents to email as attachments. For the users, this was a major timesaver and minor barrier for transitioning from one system to another.

Organisation 8b discovered the software developed by Organisation 8a online and started to evaluate and test the product as a potential solution to the document email distribution problem. During testing Organisation 8b discovered that the software was capable of fulfilling the gap, but it suffered a number of defects and lacked some of the more polished features that would be required to implement with its clients. Realising the potential for the products broader application for users of the mid-tier financial system Organisation 8b approached Organisation 8a with a proposal to brand and distribute the product within ecosystem of systems integrators and users of the mid-tier financial system.

Organisation 8b provided an environment to test and refine the software with several of its clients. After approximately two years the software reached a stable release point. Organisation 8b formed a reseller agreement to market, distribute and support the improved product as an add-on package for the mid-tier financial software. Organisation 8a remained in control of software development and the associated intellectual property.

The add-on module was highly successful and was on-sold to the majority of Organisation 8b's client base. Organisation 8b also started to push the product into the broader mid-tier financial software marketplace, which included other financial systems.

After a few years of continued success the number of sites using the software had climbed considerably. There was also interest coming from a number of larger organisations that could see the potential for the software in a broader context. At this point Organisation 8b realised that the somewhat informal reseller arrangements and the newly developed intellectual property advanced through refining the software represented a risk moving forward. Consequently Organisation 8b approached Organisation 8a to form a joint venture to continue the development and management of the intellectual property.

The software continued to be successful and new features evolved allowing the software to integrate with common database platforms and produce standardised XML based documents. The joint venture company was also approached by a large-scale business process outsourcing business to develop and licence the software as subsystem (OEM) of their services.

Reflecting on the development process through the life of the software, software engineering was performed entirely by Organisation 8a. Organisation 8b gathered and defined the requirements and undertook extensive reliability testing and support of the product during development. Organisation 8b also tested updates and new releases of the product.

Organisation 8b cited software reliability and addressing defects as the major issue for IT innovation. As a consequence they devoted considerable time and effort to reducing the risk of software defects adversely impacting users of the software.

Development of software now spans more than ten years. It has undoubtedly been successful and the participant interviewed from Organisation 8b lamented that they could have done more with the software had they devoted more time and effort. The product now reaches an interesting stage of development, where conceivably the emergence of software as a service and cloud based technologies will make document routing somewhat redundant through data integration.

4.9.1.1 Social structures

Innovation in Case 8 involved the upgrading and marketing of document routing and distribution software via a partnership between a software developer and ERP system integrator. The ERP system integrator had a number of customers willing to test and provide feedback on the innovation.

Table 4-22. Summary of actors and their roles in innovation in Case 8.

Actor	**Description and role**
The software developer	The original developer of the shareware based virtual printer software
Organisation 8a	The Organisation associated with the software developer
Organisation 8b	Systems integrator business and one side of the innovation development in Case 8.
Business owner Organisation 8b	The business owner of Organisation 8b
Organisation 8b customers	Customers of Organisation 8b who were users of a new ERP system.
ERP Partner network	The sales and support distribution network for the new ERP.
BPO organisation	Business process outsourcer.
Joint venture company	A company established to manage the affairs and intellectual property created by the innovation in Case 8.

4.9.1.2 Information technology artefacts

Innovation in Case 8 involved the development of printer driver based software that allowed for the routing and distribution based on coloured text hidden and tagged within the print document. The innovation involved a number of complementary technologies and was initially designed to integrate with ERPs for invoice and statement routing via email and fax.

Table 4-23. Summary of information technology artefacts involved with Case 8.

Artefact	**Description**
Virtual printer software	The document routing and distribution software that took the form of a printer driver.
ERPs	Enterprise resource planning applications, in this context it referred to mid market financial and accounting systems.
Intellectual property	The software code and design.
Operating systems	Mainly Windows operating systems that would run the virtual printer software
Email	Electronic mail for document routing and distribution

Artefact	Description
Fax	Fax for document routing and distribution
XML	XML formatting of printed documents for routing and distribution.
Databases	Databases that could receive routed documents.

4.9.2 Emerging themes

Following a sequence of inductive coding and analysis, eleven themes emerged for Case 8 and were arranged into four groups of related content associated with the global theme of information technology marketing innovation. The thematic network for Case 8 is illustrated by figure 4-9.

The global theme of *information technology marketing innovation* pertains to the successful redesign of a novel software product and its commercialisation or placement into new markets. The themes and their groupings in the network are summarised in table 4-24.

Figure 4-9. Case 8 Thematic network

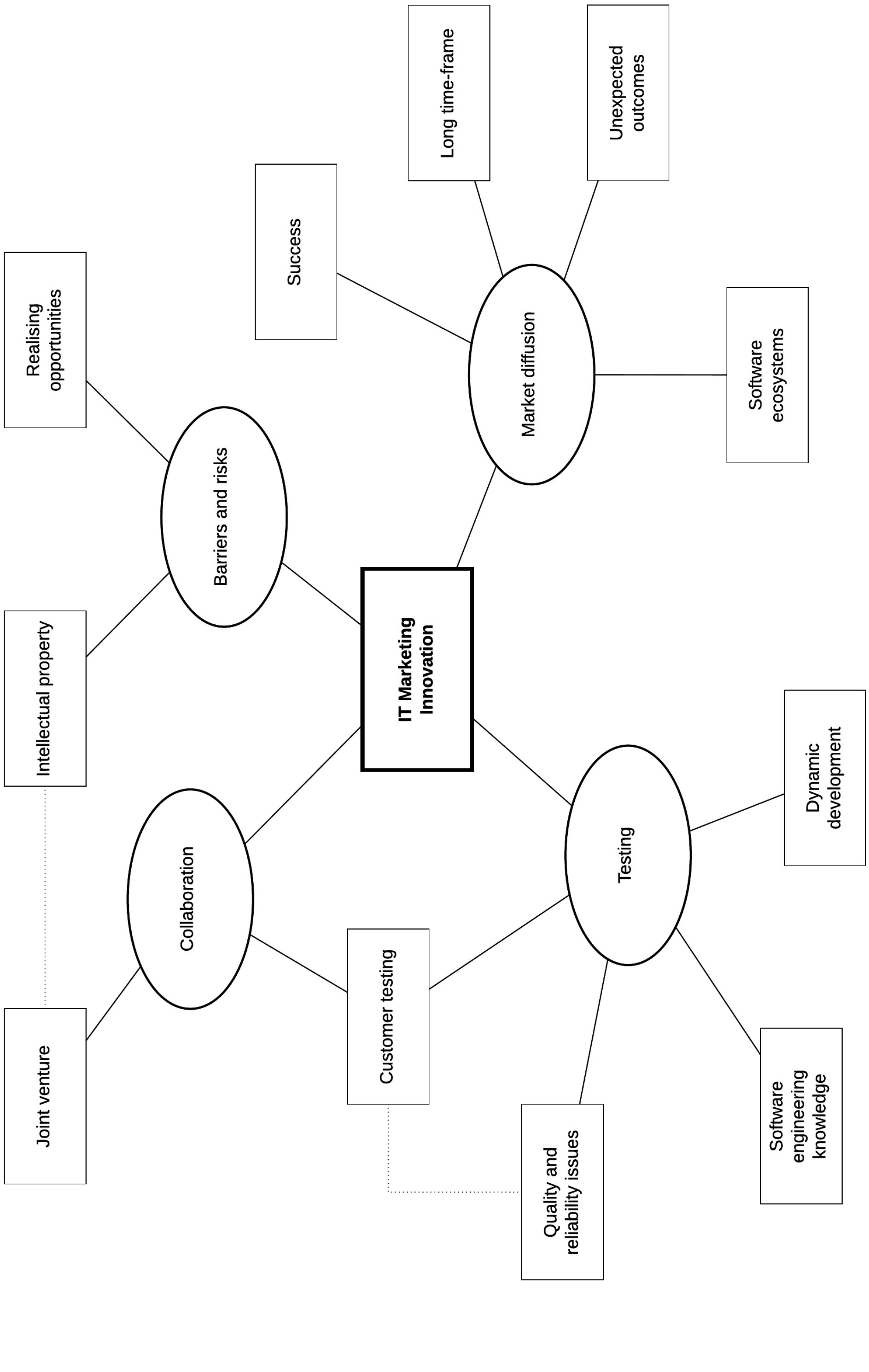


Table 4-24. Case 8 emerging themes

<table>
<tr><th>Organising Theme</th><th>Theme</th><th>Definition</th></tr>
<tr><td rowspan="4">Testing</td><td>Dynamic development</td><td>The development was driven by requirements that were created dynamically from testing.</td></tr>
<tr><td>Software engineering knowledge</td><td>Specialised knowledge of software design and development were used to improve or resolve issues from tests.</td></tr>
<tr><td>Quality and reliability issues</td><td>Software testing focused on resolving software defects and alignment its fitness for purpose with the use cases.</td></tr>
<tr><td rowspan="2">Customer testing</td><td>Testing was undertaken by users/customers of the software.</td></tr>
<tr><td rowspan="2">Collaboration</td><td>Testing was a collaborative venture with customers.</td></tr>
<tr><td>Joint venture</td><td>A formal organisation arrangement was made between the developer and systems integrator.</td></tr>
<tr><td rowspan="4">Market Diffusion</td><td>Software ecosystems</td><td>Ecosystems of users and systems integrators focused on particular software solutions were used to market and diffuse the product.</td></tr>
<tr><td>Success</td><td>Successful adoption and sales of the product into to new markets.</td></tr>
<tr><td>Unexpected outcomes</td><td>Unexpected levels of adoption and development occurred around product diffusion.</td></tr>
<tr><td>Long time-frame</td><td>Development and diffusion occurred over a long time frame.</td></tr>
<tr><td rowspan="2">Barriers and risks</td><td>Intellectual property</td><td>Issues were encountered managing intellectual property.</td></tr>
<tr><td>Realising opportunities</td><td>Opportunities potentially went unrealised.</td></tr>
</table>

4.9.2.1 Testing

Innovation activity in Case 8 involved the identification of an imperfect software solution by Organisation 8b and its subsequent design change and improvement to position the product for a specific market or markets. The development process involving change and improvement to the software was undeniably test driven and dynamic, in that requirements were effectively created from testing.

I0: “In the early days it wasn’t really production ready? [paraphrased]”

P8: “Yea, it wasn’t a business tool really”

I0: “What interactions did you have with him [developer] and the work you had to get him to do to bring it up to a commercial standard, what can you tell me about that, how did you go about that?”

P8: "It was thousands of emails and lots of Skype calls and all that sort of stuff and late hours since there is a time difference. So for us it really was almost on the fly development of the product. As we put it into a client add some or right that would be a lot better if we did this and just backwards and forwards so we probably used our clients as guineapigs to some degree."

Even as the product reached maturity testing was critical, focusing on maintaining functionality in changing technology environments such as the release of new operating systems or the integration with additional software platforms.

I0: "Possibly now you are more formalised or do you still take that approach?"

P8: "Yea, we are pretty formalised now."

I0: "You have a test process?"

P8: "Yes, the standard test documents that we have pumped through are versions that will have all of the fields mapped and has everything in it.

P8: "The big releases are for new operating systems. So 64 bit caused a lot of hassles but it did with everybody with printers. Its just one of those things."

A major issue for Organisation 8b that drove the testing focus were issues with software quality and reliability. Organisation 8b had the knowledge and experience to understand the implications of poor quality and the risks associated with unreliable software.

P8: "And I suppose reliability and testing. Most software developers no understating of the business ramifications of something going wrong or not working the way it should. Imagine [if the software] starts astray and you have got thousands of emails shooting around all over the place, that you could be sending somebody's financial documents to the wrong person. Simple little things like that. Fix one thing break three other things; you go around in the whole cycle. But his quality has improved immensely over the years and I think he understands that a lot better. Our guys don't deploy a version until we have fully tested, but it on to a couple if sites that have lower volumes, before we do higher volume sites."

Organisation 8b also had access to customers or would be users that were prepared to test the software during its initial integration. These customers provided invaluable feedback and assist to identify reliability issues and align the software features with the needs of many similar users.

P8: "To get that right and our guys doing some testing and clients giving feedback. In the early days we were actually putting the solution in an we were not charging the client, we put it in and we would say we are working on this product, it replacing [another product]. They were happy because they were not paying 50c a click for the document to go through, which is what they used to have to pay with [the other product]. So for them there was a cost saving at the end of it. It was a bit of a hassle, a bit of mucking around with bugs and thing like that."

4.9.2.2 Collaboration

Innovation in Case 5 was only made possible through a mechanism of collaboration between the system integrator (Organisation 8b) and the original software developer (Organisation 8a). Organisation 8b had initially identified the software as a potential solution for problem their customers were having migrating financial systems, but has the product was tested Organisation 8b also identified the opportunity to develop the product for other customers.

> P8: "So initially the product was really aimed more for us, it was only then that we started thing, well ok why don't we sell it to other resellers. That's when we went out to the [product X] community and they loved it and wanted to buy it and then we started to think well, it doesn't matter it's a product agnostic it doesn't matter which product you use it with, why don't we start approaching other ERP solutions and that's when we got into SAP and we done Arrow. We done Dynamics, we done Triumph, we done lots and lots of different products."

Both organisations entered into a collaborative process where Organisation 8b would facilitate testing of the software and gather requirements for change, whilst Organisation 8a would implement the changes.

> P8: "[Organisation 8a] was responsible for development of product and licensing our product. [Organisation 8a] was the actual key marketing and support and sort of handled end-user stuff."

This arrangement carried forward several years until both partied acknowledged their achievement in repositioning the product and entered into formal arrangements with respect to their collaboration by establishing a joint venture company.

> P8: "As that built up we then decided that well, it was a fairly loose arrangement with [Organisation 8a] there was nothing you know other than a few a emails and a few conversations and that sort of stuff. So we decided to setup [Joint Venture Coy] which was a joint venture company between [Organisation 8b] and [Organisation 8a]."

An additional and essential level of collaboration was also maintained during the early stages of the innovation between Organisation 8b and several of its customers (see 4.9.2.1).

4.9.2.3 Market diffusion

Organisation 8b was initially very successful in diffusing the repositioned software through its customer base. It then carried the same success forward into a single financial software ecosystem where it had good connections with the manufacturer and the partner network across Australia. Organisation then managed to adapt the product for use with other mid-tier financial systems. Knowledge and access to the software market-ecosystems appeared pivotal in the products success.

A redesigned and repositioned product the software successfully evolved of a long time frame. After a decade the product had attained some 2,800 sites worldwide. The joint venture approach allowed them to restructure the licensing model to generate improved revenue and software was generating ongoing maintenance revenue from the existing user base.

P8: "What we sell is annual maintenance a lot. Based on the client base there is some good ongoing revenue as well… There is good revenue."

As the software became more widely diffused a number of larger originations took interest in the product. Unexpectedly as a result of this interest Organisation 8b was approached with a proposal to license the software as a subsystem (OEM) for a large business process outsourcing (BPO) vendor. The BPO OEM license was a substantial revenue generating opportunity. The proposal called for software license model built on a per click per document basis and the proposal was looking at processing 5 to 10 million documents per annum.

P8: "We also taken the opportunity to start doing OEM deals as well and this is were we started to do quite well as well. About two years ago we signed a contract with a company called [Company X] which is in the business of BPO (Business Process Outsourcing) and they have OEM'd the product, we have licensed that to them and that's based on a per click, per document, which is quite large. There plans are to be up around 20,000 sites and processing anything up to there numbers 5 to 10 million documents a year, which is good and we are still looking for other opportunities like that as well. So that's a very cut down version of the product that does quite specifically converted documents into XML and sends it to their BPO service."

4.9.2.4 Barriers and risks

Both organisations approach to the marketing innovation was initially informal and conservative. There is little evidence of any major capital inputs with both party's major contributions being in-kind labour to support various innovation activities.

I0: "Have you ever had to call in external funding?"

P8: "Its been funded by [Organisation 8b], the other business, in the same way supported by [Organisation 8b] staff, the resellers that sell the product ring in here and they get supported by our support team, so we just do a journal entry at the end of the year to cover the costs of the wages into the other company to do it. So [Organisation 8b] has in effect funded the start-up."

Any need to manage and protect the intellectual property was not really apparent until the BPO vendor approached the organisations. The BPO vendor wanted assurances about patent liability and it was discovered that a patent had been taken out on a similar colour based recognition process. However the patent post dated the innovation in Case 5 and this provided a safety net in terms of patent breach.

P8: "We did a bit of investigating and found that there is a patent out there for the use colours that loosely matches what we are doing, but that our work predates that, so in effect we are protected as long as we remain within the bounds of what we initially started to do. Because apparently … what we found was that in the US, it's the first person to actually do a particular thing, that has the right to do it, were as the rest of the world it's a matter of who ever patents it first is the person that actually has the patent, but the person who invented it still has the right to use it for profit within the bounds of what it was originally designed for … we felt that we were quite safe as long as we didn't start creating new applications and new things that were doing slightly different things."

Both organisations also assessed the option for patenting the technology but found the cost that was projected to be upward of $2 million dollars to be somewhat prohibitive.

P8: "The issue obviously has always been that a patent quite expensive to take through. We had some looks at it and it was about $2 million, to get a patent fully authorised, which is ridiculous. So we decided we will just maintain our single executable that is Autodoc.exe and that is still the basis of these OEM products as well. They are just slightly labelled differently, but from a code perspective they are still the original product and that way we are protected from the way we operate."

Interview transcripts show the participant from Organisation 8b was reflective of the success and achievement associated with the innovation in Case 5. He openly projected a decline for the product, as document routing was likely to become less of a requirement moving forward with the evolution of integrated cloud based technologies. He also lamented the conservative long-term development suggesting that it may have been possible to raise more revenue through broader diffusion had more effort been put into marketing the product.

P8: "From a sales perspective we still we could probably spend a lot more time on it, but we don't, I tend to get side tracked …"

P8: "Look I think the product five years if we had of put in someone to manage it and grow it, it would be a lot bigger ..."

P8: "I look back on it an lament that we probably could have done a lot more with it over the years."

P8: "I think it will be a product that will slowly drop off at some point. Its one of those things that once everyone moves to the cloud and things change and finance applications and other applications start to integrate a lot of this stuff in there, I think it has got a limited life span to some degree. I think its probably another 10 or 15 years away but at some point it not going to be something that's going to be around forever. Because I think the world will change the way its delivering information and things move around, it built around printing."

4.10 Case 9 – Gamification application for enterprise social networks

4.10.1 Context

Case 9 follows an information technology product innovation associated with the development and commercialisation of rewards recognition system (software) developed a systems integration business (Organisation 9) that specialised in the implementation, deployment and customisation of IBM software platforms. The software was principally designed as add-on module that facilitated user adoption of IBM's enterprise social collaboration platform – IBM Connections.

A unique feature of the software innovation in Case 9 is the utilisation of game mechanics or gamification theory within the software functionality. The software introduces techniques such as missions and challenges, peer acknowledgement and leader boards to recognise and rank contributors on the basis of the quantity and quality of their contributions. The use of these techniques facilitates the adoption the IBM Connections social collaboration platform by making it more enjoyable and motivating to use.

The IBM connections platform would be best described as a corporate version of Facebook. Organisation 9 was an early adoption partner for the platform and commenced development of the rewards recognition module in order to build its knowledge and experience working with the platform. Organisation 9 also had a desire to differentiate itself as a leading systems implementation and integration partner for IBM Connections.

Organisation 9 already had a number of experienced developers with some familiarity with platform on which IBM Connections was developed. In the initial stages one of the developers advanced an interest in the application of game mechanics in social media applications. Organisation 9 drew on this knowledge and the experience using various social platforms that used gamification to facilitate content contribution.

Using fairly informal development methods Organisation 9 was able to develop a working prototype and have one of its customers test and provide feedback. It was then able to take an initial release of the product at a global IBM partner conference for review and assessment by other users and other IBM business partners. Feedback from the conference was described as overwhelming and Organisation 9 walked away from the conference with three to four good prospects to purchase and use the product, and four to five partners wanting to resell the product.

At this point Organisation 9 realised that the software had significant potential to become a commercial product. As a consequence it changed its development investment approach and placed additional resources into further developing the product. Sales continued to grow and it started to attract interest from some large multinational businesses with literally hundreds and thousands of users.

From a development perspective Organisation 9 concentrated on adding new features. They introduced an agile development approach and focused on quick and short release cycles. They also introduced a customer council to provide feedback and new feature requests.

As development progressed Organisation 9 found itself challenged in a number of areas. From a software engineering perspective it needed to address issues with version control and build management. Organisation 9 took on a relatively sophisticated development toolset provided by IBM (Rational Team Concept) that allowed them to run with their agile methodology, and at the same time automate software builds and version control. It also provided greater levels of team collaboration.

Design, version and build management activities were also further complicated with the release of a new version of the IBM Connections platform. Organisation 9 soon found itself dealing with the complexities of supporting multiple versions across different customers and the desire to maintain improvements in both platform versions.

Organisation 9 also found that it needed to allocate a focused development team to the task of software design and development. Traditionally as a systems integrator their development teams were involved in software support and general service delivery. Organisation 9 found that operational calls on developer resources were detrimental to the new development initiative.

Beyond technical and development issues Organisation 9 also found challenges with the commercialisation aspects of the innovation. Dealing with large multinational organisations with large numbers of users changed Organisation 9's approach to software licensing. Decisions needed to be made about the best approach to it channel architecture. Organisation 9 was unsure who was the best partner to resell their software. Significant effort was placed into marketing the product and global issues emerged trying to manage collections and payments.

The information technology product innovation investigated as part of Case 9 was highly successful for Organisation 9. The development and commercialisation of the rewards recognition module resulted in a broad diffusion of the innovation and significant revenue. The development also allowed Organisation 9 to improve its software engineering capabilities and its knowledge of the IBM Connections platform; possibly to the extent that they are a global leader with respect to their knowledge of the platform. Development and commercialisation of the software was also undertaken and completed in a relatively short timeframe.

4.10.1.1 Social structures

Innovation in Case 8 involved the development of rewards recognition system maintained as a module to work with an enterprise social media platform. Innovation involved collaboration with users and partners.

Table 4-25. Summary of actors and their roles in innovation in Case 9.

Actor	Description and role
Organisation 9	Organisation 9 was a systems integration business specialised in the implementation, deployment and customisation of IBM software platforms.
Software developers	Software development staff working with Organisation 9
Users	Users of the enterprise social media platform and ultimately customers for the rewards and recognition module.
Gamification experts	Experts in the application of game mechanics or gamification theory to software design.

Platform vendor	The vendor of the enterprise social media platform.
Platform Partner network	The sales and support distribution network enterprise social media platform and other related platforms.
Software distributors	Possible and eventual distributors for the rewards and recognition module.

4.10.1.2 Information technology artefacts

Innovation in Case 8 involved the development of a rewards and recognition module to improve the adoption of an enterprise social media platform. The software was dependent on the enterprise social media platform.

Table 4-26. Summary of information technology artefacts involved with Case 9.

Artefact	**Description**
Rewards and recognition software module.	The software innovation in Case 9 that utilises game mechanics introducing techniques such as missions and challenges, peer acknowledgement and leader boards facilitates the adoption the enterprise social media platform.
Enterprise social media platform	The social media platform that Organisation 9 implemented and the basis for the rewards and recognition software module that aimed to improve adoption rates.
Java and J2EE	The Java and J2EE development platform was used to develop the rewards and recognition software module.
Development toolset	A toolset that allowed Organisation 9 to run with their agile methodology but at the same time automate software builds and version control. It also provided greater levels of team collaboration.

4.10.2 Emerging themes

Following a sequence of inductive coding and analysis, fourteen themes emerged for Case 9 and were arranged into four groups of related content associated with the global theme of information technology product innovation. The thematic network for Case 9 is illustrated by figure 4-10.

The global theme of *information technology product innovation* pertains to the development and successful commercialisation of a novel complementary information technology solution for use with an enterprise social media platform. The themes and their groupings in the network are summarised in table 4-27 below.

Figure 4-10. Case 9 Thematic network

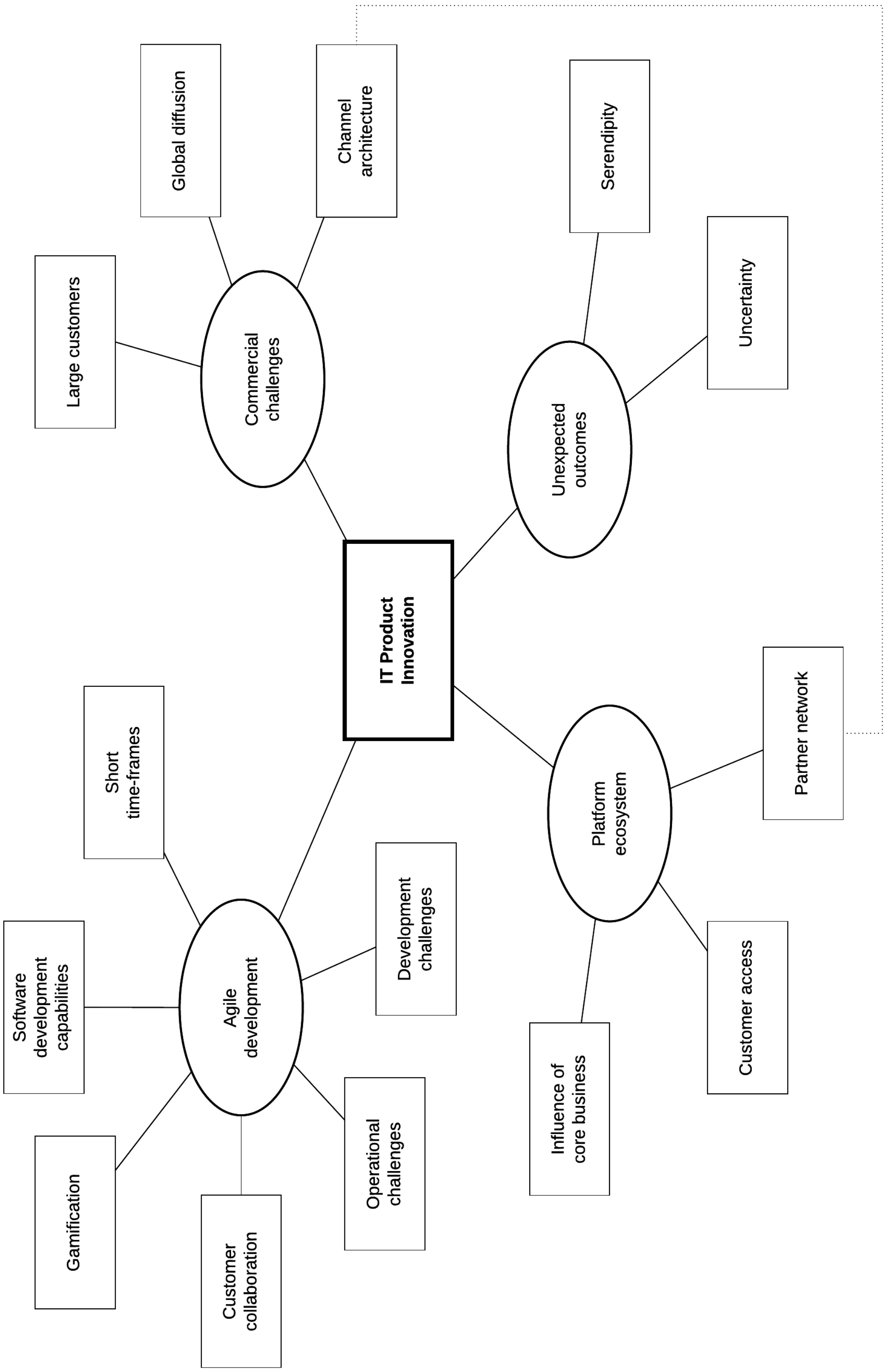


Table 4-27. Case 9 emerging themes

Organising Theme	Theme	Definition
Agile development	Gamification	The application of game mechanics and techniques in software design.
	Software development capabilities	Capabilities associated with software planning design, programing and testing. Including the methodologies for such.
	Customer collaboration	Interaction with customers to test and provide feedback on the software features and reliability.
	Operational challenges	Challenges associated with resourcing and running development activity.
	Development challenges	Challenges associated with the technical elements (plan, design, build and test) of software development.
	Short time-frames	Short period of time to complete software releases.
Platform ecosystem	Influence of core business	The influence of the organisation following the systems/solution integration business model.
	Customer access	Access to a network of platform users and would be customers.
	Partner network	Access to third party solution integrators and resellers (partner networks) associated with the same platform.
Commercial challenges	Large customers	Dealing with customers that had extremely large user bases (in the thousands).
	Global diffusion	Internationalisation of the software and doing business with business in different countries.
	Channel architecture	Determining the appropriate way to organise the product sales channels and who would be selected to resell the product.
Unexpected outcomes	Uncertainty	Difficulty in predicting or forecasting the outcome of innovation activity or the decisions around innovation objectives.
	Serendipity	Unintentional desirable outcomes albeit made possible by perceptive innovation activity.

4.10.2.1 Agile development

The software developed as part of the innovation in Case 9 was adaptive and incremental and whilst it was initially informal, Organisation 9 followed the general principles of an agile development process. Innovation activity in Case 5 was characterised by informal planning, customer collaboration and short development/release time frames.

P9: "But a lot of the little ideas on how things should work is coming from customer feedback. We try to build that into our development plans as best we can."

P9: "It was very sort of Agile, very quick releases, very sort cycle for release."

Organisation 9 was also forced to address particular challenges in relation to the organisation of its resources so they were focused on development and not distracted by operational support problems. Organisation 9 also had to adopt new development techniques to assist with the speed and efficiency required to meet the demands of their customers (and potential customers).

P9: "The way then matured into was using IBMs Rational toolset. We used Rational Team Concept, which enables you to do all of that sort of Agile planning as well as release management and version control and configuration management and what have you and automatic builds."

P9: "So those tools enabled us to be far more nimble and quick and responsive."

P9: "One of the challenges we have always had, because we are a consulting firm, is that the people that were building our software products were often the people doing consulting work as well. So our software products would always end up getting neglected because we too busy. The tyranny of now, you have got to respond to customers."

Two important knowledge based processes also appeared to be present within the innovation activity for Case 9 – (1) the application of game mechanics to software functionality; and (2) the evolution and improvement of software engineering and development capabilities within Organisation 9.

The application of game mechanics (gamification) to drive users to contribute content to the enterprise social collaboration platform as a novel and unique element of the innovation in Case 9

P9: "So fundamentally we, I say reward and recognition because the other term for it is gamification, so it leveraging game mechanics or game theory using tactics such as leader boards and achievement levels and badges and missions and challenges and those kind of game tactics to play on peoples psychology I guess, to get more involved. That's what it is."

Prior to commencing development Organisation 9 had limited knowledge of gamification and how it could be used in this context. Interview transcripts cite one of the developer's personal experiences using a number of consumer social media platforms and further investigation into gamification theory via openly available books and experts willing to impart knowledge.

P9: "Part of it was that I had read some books on gamification, I found experts around the world. There is this guy named Gabe [Zichermann], I forget his surname, he is like a gamification person, I read his book."

Organisation 9 had already successfully developed a number of software products that it used to highlight the organisations systems integration capabilities. Some products were commercially successful whilst others were not so much commercial but successful in connecting the organisation with potential customers. Hence, Organisation 9 already possessed a range of software development capabilities. However development undertaken in conjunction with Case 9 allowed the organisation to grow these capabilities significantly. Organisation 9 reported improvements in its knowledge and application of new software engineering methodologies and the application of new tools to improve the efficiency and speed of development. Organisation 9 also increased its knowledge of the enterprise social media platform and raised the organisations profile as a global knowledge leader in relation to that platform.

P9: "I guess we got much better at our software development methodologies, using tools like Rational, but that group as well, the depth of knowledge and experience of the Connections platform is, I honestly think second to none in the world. We know stuff about the product that IBM doesn't know."

4.10.2.2 Platform ecosystem

Organisation 9 had been in business for many years and its core business was value adding and systems integration using various IBM platforms. Organisation 9 had an extensive background with IBM Lotus Notes and Lotus Domino and was an active IBM partner. Organisation 9's experience working in the IBM partner network and its experience with partner events and marketing appears to have provided some insight on how to access customer and distribution channels through the network.

Organisation 9 core business was the primary influence for starting the innovation in Case 5. The software was initially developed to showcase their expertise in implementing the enterprise social collaboration platform. It was anticipated that a successful development would differentiate their business from other integration partners.

P9: "It was very much around (1) trying to come up with ideas to differentiate us and add value over and above what our competitors can do; and (2) identifying a problem, that being driving adoption and trying to think of ways of addressing that problem."

Organisation 9's previous experience with IBM's global trade event called Lotusphere had them organise and prepare the software innovation around that event, realising that it would give them access to customers and partners. The marketing initiative at Lotusphere was from accounts very successful and the catalyst for further development and sales.

P9: "We launched it a week before the Lotusphere Orlando event, announced it and put out a press release and really leveraged our network around the world, got it on some podcasts and really leveraged the whole community to get the word out there. Then at Lotusphere it was overwhelming, incredible. We pretty much left Lotusphere with 4 or 5 partners that wanted to sign up to sell it, we had 3 or 4 good prospects to sell it to as clients and since then we have. Some of them bought it in March, one of them from Lotusphere just now bought it about a month ago."

4.10.2.3 Commercial challenges

Beyond the technical development Organisation 9 also experienced a number of commercial challenges marketing, selling and distributing the software.

The first issue was associated with its global diffusion. Previously Organisation 9 had not sold or marketed a product on to international markets. All of a sudden it found challenges with finance and "getting paid" and also dealing and interacting with customers on the other side of the world.

P9: "Its been a big learning curve and even like just the whole selling internationally, simple things like getting paid… The European countries all want called an IBAN, which is an international banking account number. Australian banks don't have IBANs. We have like Swift codes. The European's don't understand that and you send them our details and no they want the IBAN and what is this bloody IBAN. So we find out its easier to get an overseas bank account. So there are all sorts of aspects that we have had to learn about."

The software product had also attracted a number of large multinational customers with user bases in the thousands. Organisation 9 found that the needed to rethink the licensing model and address the demands of larger customers with more elaborate IT governance models.

P9: "A lot of the medium and small customers are quite happy to sort of take what they get, but the bigger ones, they are bigger and demand a lot more. So you kind of realise that. Even from a product perspective, pricing perspective an all that, you need to take that into consideration. We have rejinked the pricing, I'm thinking at the moment about rejigging it slightly more. You kind of realise when you get to really big, then they don't really care on the price list at all, because they are not just buying the product either, they are buying services and engagement ongoing, a lot of stuff. It becomes a different proposition."

Organisation 9 also found it challenging to design its partner or reseller channel, selecting the right partners to distribute the product in different countries etc.

P9: "It has been a challenge. Enabling your partners and finding the right types of partner and what's a good partner and what's not a good partner."

4.10.2.4 Unexpected outcomes

Innovation in Case 9 was a planned and deliberate activity to create a software product. However the initial objective was not to create a stand-alone commercial product but rather a product that would showcase Organisation 9's expertise with the IBM Connections platform.

P9: "So we went in to it not really thinking that we would build commercial product, we thought maybe could be commercial but it was really more about trying to build something that was innovative and differentiating from our competitors and staying steps ahead of all our competition, just always trying to stay ahead of the pack."

Development was undertaken with a high degree of uncertainty.

P9: "Now we thought it was a good idea, we thought this was cleaver and I think that this will actually work and have value, but we honestly didn't know whether or not it would be commercial."

The software becoming commercially successful was not by chance or good fortune. Organisation 9 had in fact put the appropriate conditions and resources in place to develop software. However in pursuing a different objective for the software it discovered a market for the software in its own right. Thus the software becoming a commercial success appeared to be somewhat serendipitous.

P9: "we really didn't really expect to make money out of it, it was more again just to differentiate, to innovate and create some coolness around what we were doing."

4.11 Chapter summary and reflections

In this chapter an analysis was conducted on data collected in relation to nine case studies of innovation that involved the use and/or development information technology. Interview transcripts and field notes were analysed independently to provide a within case interpretation of the activities and events (themes), social structures and information technology artefacts experienced by participants involved with the innovation.

The within case analysis provide a rich description of each case within a unique context (Stake 2013).

Themes, descriptions of social structures and descriptions of the information technology artefacts relating to each case are utilised in the second phase of analysis in Chapter 5 to conduct a cross case analysis of innovation involving the use and/or development information technology in the nine case studies associated with this research.

5 DATA ANALYSIS PART 2 – CROSS CASE ANALYSIS

5.1 Introduction

This chapter presents the second phase of data analysis exploring the themes, social structures and information technology artefacts across all cases. Cross-case analysis allows themes and concepts to be evaluated and refined in different context (Darke, Shanks & Broadbent 1998), deepening understanding and explanation, and addressing tensions between the particular and the universal (Miles & Huberman 1994).

As described in Chapter 3, this phase of analysis follows the guidance provided in Miles and Huberman (1994) relating to cross cases analysis. Within case data was partitioned in terms of the high-level research themes described in the heuristic device in Chapter 2. Data was then organised using cross case meta-matrices and clustered around related themes, social structures and information technology artefacts, acknowledging that relationships can be formed by both similarities and differences.

The sections that follow represent the cross cases analysis for each partition.

- Section 5.2 examines data relating to the decision to innovate across cases. It explores data that may assist in understanding the reasons, motivations and/or objectives driving innovation.
- Section 5.3 examines data relating to innovation activity across cases. This included data that related to development activities that lead to the implementation of innovations such as research and experimental development, the acquisition of capital goods and services, the acquisition of external knowledge and activities associated with innovation deployment.
- Section 5.4 examines data relating to innovation outcomes across cases. This section looks at data that may assist with the understanding the economic, social and technological outcomes associated with innovations, including factors influencing the success or failure of innovation and the impact of innovation in terms of organisational performance. This section also looked at the innovations degree of novelty and the scope of diffusion.

The chapter concludes summarising the cross-case analysis process introduces the next phase of interpretation and discussion of the analysis in Chapter 6.

5.2 Research theme – the decision to innovate

5.2.1 Introduction

In Chapter 2, the decision to innovate is identified as important antecedent for innovation activity. This section explores the research data across all cases relating to the reasons, motivations and objectives for innovation.

Results from within-case analysis in Chapter 4 pertaining to emerging themes, social structures and information technology artefacts were filtered for relevance to the research theme and then re-examined for relationships across cases.

- Section 5.2.2 examines the emerging themes using a case ordered meta-matrix. A clustered thematic map is then presented to provide an overview of the themes present across cases. The consolidated themes are then described in the context of the relevant cases.
- Section 5.2.3 examines the social structures present across cases. Within case data was consolidated by grouping social structures into roles and actor archetypes and displaying the results in the context of relevant cases.
- Section 5.2.4 examines the information technology artefacts present across cases. With-in case data was consolidated and grouped into classes of information technology and displaying the results in the context of relevant cases.

5.2.2 Themes

Within case themes were identified in chapter 4 through a process of inductive coding. Themes, associated codes, field notes and analytic memos where reviewed for any connection or relationship to innovation decisions. The relevant themes were then identified in conjunction with the cases and a summary of memos relating to the decision to innovate. A case ordered display is presented in Table 5-1 that summarise the relevant themes and context.

Table 5-1. Case ordered display for themes relating to the decision to innovate.

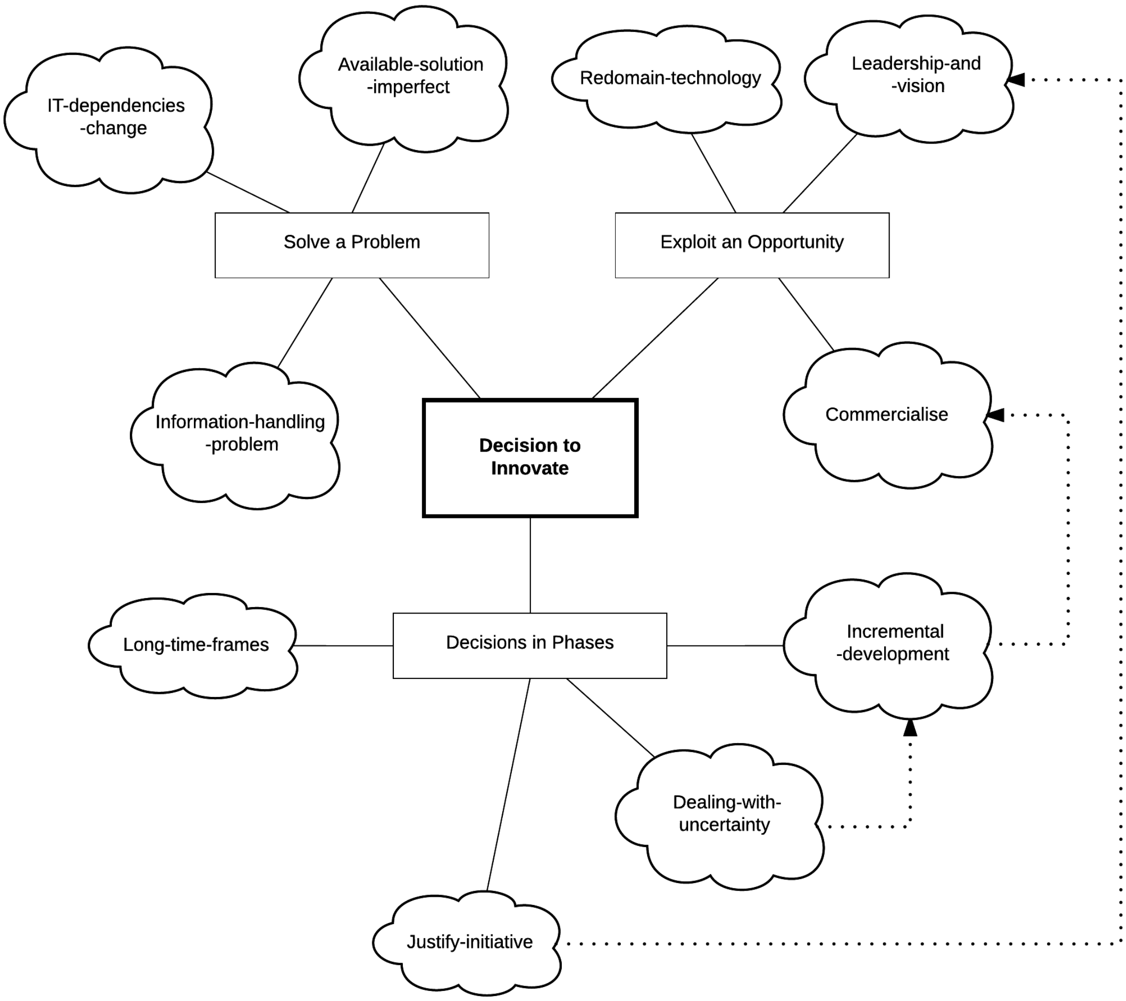
Case	Case Summary	Themes
1	Organisation 1 was Unable to find a suitable POS solution at an affordable price. Management ultimately decided to develop software in-house to meet their requirement. Decisions to take this direction were influenced by the organisations low cost business model, as more expensive solutions were available at the time. Following the initial innovation, software platforms and infrastructure were changing rapidly and new platforms had become available making the initial platforms near obsolete. Further decisions were made to redevelop software to mitigate various platform and equipment dependencies. Additional functionality was added in response to business requirements. Part of the development of this functionality was temporality outsourced to an external software developer.	<u>Solution-selection-problem</u> Imperfect-existing-solutions+ Business-model-influence Constrained-by-infrastructure-costs. <u>Incremental development</u> (Decision-in-phases+) Continuous improvement Long term evolution <u>IT platform changes</u> IT market innovation IT dependencies Requirements-from-testing
2	Innovation in Case 2 was initiated by the management of Organisation 2a when they recognised that there were a number of problems with the existing sales process. Sales staff utilised a basic layout and design (BLAD) style catalogue to facilitate sales with customers in conjunction with PDA barcode readers to capture the orders. Maintenance of the BLAD style catalogues incurred significant overheads and they were bulky for the sales staff to transport and use in the sales environment. However the BLAD catalogues were seen as an important marketing and sales facilitation tool by sales staff and management. The sales order entry process was also seen as problematic and despite the use of barcodes, the process was slow and cumbersome and prone to human error in terms of stock and barcode selection Management recognised the potential for information technology to facilitate the desired business process improvement and initiated the innovation. The innovation progressed in phases with new functionality being added for promotional marketing and sales intelligence.	<u>Solve-a-business-problem+</u> Information-handling-problem+ Unhappy-with-existing-system+ <u>Incremental-development approach</u> Phased development (Decision-in-phases+)
3	Following growth of the business found it needed solution to track stock and understand the costs involved in farming. Farming activity and production information was tracked by several large spreadsheets that had become unwieldy. Consideration was given to utilising commercial of the shelf software (COTS), but critical features were not present for the farming context faced by Organisation 3. Management initiated a project to develop software specifically for their needs.	<u>Solve-a-business-problem+</u> Information-handling-problem Unhappy-with-existing-system+ Imperfect-solutions+
4	The decision to innovate was present in two phases. Initially the decision was driven by a "place branding strategy" initiated from within the marketing department.	<u>Exploit-an-opportunity+</u> Information-handling-problem+ <u>Strategic-vision</u>

Case	Case Summary	Themes
	Decisions were made to support the strategy by utilising online booking services for properties and attractions. Then driven by the initial success and problems handling booking inventory across multiple systems and services, further innovation activity commenced to integrate the various systems and databases that were used to manage bookings and availability with the online services.	Business-knowledge Marketing strategy <u>Incremental-evolutionary approach</u> (Decision-in-phases+)
5	The decision to innovate followed an incremental and staged process of testing the feasibility of LIDAR technology to collect data about forest resources and then ultimately deciding to proceed with implementation on the basis of the initial stages. Organisation 5 was facing a number of issues in relation to the collection of data associated with inventory measurement. It was also finding that the skills for interpreting data using its current methods were becoming difficult to source. A decision was made to explore the feasibility of using LIDAR technology to capture data about height. However the data collection demonstrated additional applications were possible for understanding forest terrain and structure. After several years and stages of testing a business case was made to adopt LIDAR data collection across the organisations entire inventory.	<u>Solve-a-business-problem+</u> Information-handling-problem+ Skills-availability+ <u>Exploit-an-opportunity+</u> Re-domain-technology+ Multiple-applications+ <u>Experimental development</u> (Decision-in-phases+) Scaled approach Re-domain-technology Long cycle-time
6	Innovation activity arguably spanned a long period of "pre-establishment" where the innovation was conceptualised some time before a commercial implementation was initiated. The conceptualisation phase was initiated in response to the problem of clinical medication management in the hospital context and the associated functionality gaps in software used to support hospital based pharmacists. End-user developed software tools unintentionally became prototypes for future developments. The opportunity for commercialisation was not realised until some years later and following subsequent research into the issue of clinical medication management. However the decision to innovate appears ultimately driven by the disillusionment of the founder of Organisation 6 and his experience with progressing outcomes in the public health and academic research context.	<u>Exploit-an-opportunity</u> <u>Imperfect-existing-solutions+</u> <u>Experimental development</u> Decision-in-phases+ Solve-a-problem (Information-handling-problem+) Commercialisation+ Disillusionment-with-outcomes+
7	The decision to innovate occurred at multiple phases or stages of innovation. The innovation was initiated as a research project where the chief investigator was interested in exploring the user acceptance of interactive multimedia content and technology for health education outcomes within a remote indigenous community. The innovation then moved through various stages of diffusion where further decisions were made to improve and enhance the user experience and reliability of systems. In the early phases partnerships and support were provided by academic institutions and healthcare organisations.	<u>Experimental development</u> Phased-approach (Decision-in-phases+) <u>Leadership</u> Entrepreneurial Domain experience <u>Challenges</u> Funding

Case	Case Summary	Themes
	At the most recent stage of development a decision was made to organise the project into social business enterprise (with the support of an incubator) that could become economically and technologically sustainable in delivering improved health outcomes using information technology. At all the decision points the project leadership provided the vision and drive to continue innovation.	Institutional-organisational <u>Commercialisation</u>+
8	The decision to innovate was initially made to solve a document routing problem that had been introduced to Organisation 8b's customers that were migrating their ERP systems from one vendor to another. The business owner of Organisation 8b found software developed by the software developer (Organisation 8a) that meet some of the requirements, but was also unreliable. The business owner of Organisation 8b initiated an agreement with The software developer to modify the product to address the reliability issues and add new features to meet their customer requirements. After successfully implementing the software with Organisation 8b's customers, Organisation 8b initiated further diffusion to other users of the ERP community through the vendor's partner network. It then expanded to other ERPs and eventually caught the attention of larger software/service vendors. Organisation 8a and Organisation 8b then formed a joint venture to adequately manage and support the software innovation and intellectual property.	<u>Solve-a-business-problem+</u> Document-routing+ <u>Testing</u> Quality and reliability issues <u>Exploit-an-opportunity+</u> <u>Market Diffusion</u> Success Unexpected outcomes Long time-frame (Decision-in-phases+) <u>Collaboration</u> Joint venture
9	The decision to innovate was driven by a desire by Organisation 9 to differentiate itself within the market space for implementing IBM's enterprise social collaboration platform. Organisation 9 was commenced the development of a software module that would facilitate user adoption of the enterprise social collaboration platform. The product was launched at an IBM partner network event and attracted considerable interest, at which point a decision was made to take the platform to a commercial level.	<u>Solve-a-business-problem+</u> User-adoption+ <u>Exploit-an-opportunity+</u> Serendipity <u>Agile development</u> Software development capabilities (Decision-in-phases+) <u>Platform ecosystem</u> Influence of core business Customer access Partner network

Themes identified in table 5-1 where further analysed and consolidated across cases. Ten themes emerged that were clustered into three high level organising themes that were interpreted as influencing innovation decisions. A thematic map provides an overview consolidated and clustered themes in figure 5-1.

Figure 5-1. Thematic map for consolidated and clustered themes for the decision to innovate.



Themes are further elaborated in the following sections describing the clustered organising theme along with the consolidated and related themes with their within cases instances.

5.2.2.1 Solve a problem

For the cases under study the decision to innovate appears to be influenced by the need to solve some form of problem. Several themes appeared common across many themes: (a) the need to address information collection, storage, processing and distribution problems; (b) responding to external changes in existing information technology systems and platforms for which products, services or processes where dependent upon; and (c) being unable to find an appropriate fit for purpose information technology solution to meet a specific organisational or business requirement or where existing solutions were no longer meeting requirements.

Table 5-2. Solve a problem consolidated themes.

Consolidated Theme	Within case instances
Available-solution-imperfect Existing solutions either in p[lace or available externally were unable to meet the organisational or business requirements. In many cases solutions did exist but they did not meet the quality (fitness for purpose) criteria deemed acceptable by the innovator. In Case 1 POS solutions were available in the marketplace but there were perceived as expensive to implement and required access to wide area network services which were either unavailable or expensive at the time of innovation. In Case 2 a system was already in place but the organisation was unhappy with it performance. In Case 3 solutions in the marketplace did not address processes peculiar to the industry in the context of its location. In Case 6 existing solutions did not address an entire sub function of pharmacy practice that was used in a clinical setting. Even when an initial solution was designed the innovator admitted it still fell short of solving the original problem and set about on a redesign. In Case 8 a solution was found but it required significant technical modification to meet the customer needs. In Case 9 the platform used as part of its core system integration business had issues with user adoption.	C1.imperfect-existing-solutions C2.nothing-suitable C2.unhappy-with-existing C3.imperfect-available-solutions C3.unhapy-with-existing C6.disillusionment-with-outcomes C6.imperfect-existing-solution C8.solve-a-problem C9.core-business
Information-handling-problem Possibly inherent in the design of information technologies is the fundamental purpose or objective of being concerned addressing with information handling type problems. Data collected from several cases and the themes identified within cases demonstrate that problems associated with the collection, storage, processing and distribution of information or data were the main reason for undertaking innovation. In Case 2 the organisation was confronted with the problem of keeping large product catalogues up to date and easily distributed for use by sale staff and customers. In Case 3 the organisations was losing track of farm production control information and needed to collect and analyse this data to understand its operations. In Case 4 a successful marketing strategy created significant data re-entry overheads for maintaining inventory across several systems. Innovation focused on automating transactional workflow between systems and online services. In Case 5 the organisation was using labour intensive information processing techniques for which they had skill availability issues with. The organisation turned to LIDAR data collection to automate and replace the labour intensive methods with new, superior analytical techniques. However the organisation had to solve issues with data	C2.information-handling-problem C3.information-handling-problem C4.information-handling-problem C5.skills-availability C6.information-handling-problem

Consolidated Theme	Within case instances
storage, processing and analytics to make this work. In Case 6 existing systems were not capturing or providing the information needed by clinical pharmacists to adequately perform their roles.	
IT-dependencies-change Another feature of information technology is the modular nature of its design and the subsystem or related system dependencies that are create in assembling solutions. Many innovations appearing within the case studies involved the assembly of several IT artefacts with various IT operating dependences. Innovation with the information technology marketplace often made various operating systems or platforms redundant or obsolete. Several cases demonstrated evidence of a dependent application, platform or operating system changing prior or during innovation activity. In some cases the change was factor in commencing innovation (Cases 1, 5). In other instances changes during innovation activity allowed for further innovation or required adaption to maintain innovation (Cases 1, 2, 7, 8, 9) In Case 5 market innovation and diffusion of LIDAR technology increased the availability and affordability of LIDAR equipment and this was the catalyst for commencing innovation. In Case 9 within a relatively short time-frame version changes in the platform it was building upon created development challenges and new problems to solve in maintaining multiple versions of its product.	C1.IT-market-innovation C1.IT-dependencies C2.infrastructure-constraints C5.redomaining C7.technology-advancement C8.technology-market-changes C9.developemnt-challenges

5.2.2.2 Exploit an opportunity

For the cases under study the decision to innovate appears to be influenced by opportunities to exploit information technology solutions for commercial gain or internal organisational benefit. The concept differs from problem solving, which targets solving specific difficulties or issues and is oriented towards using favourable or advantageous conditions that would or could be created by the development or introduction of new or improved information technology. In many cases opportunities were anticipated and engaged upon through an entrepreneurial process and in most instances targeted direct commercial outcomes. Two cases also exploited opportunities associated with technology being used in other industrial contexts.

Table 5-3. Exploit an opportunity consolidated themes.

Consolidated Theme	**Within case instances**
<u>Leadership–and-vision</u> In many cases the decision to innovate was driven by entrepreneurial decision making where opportunities where identified and acted upon by senior stakeholders or organisational groups with limited or incomplete information at hand. The process also appeared implicitly linked to uncertainty. This theme was identified in all ICT producing organisations, but also present in one of the Non-ICT producing organisations. In Case 4 the organisation's marketing department embarked on a new marketing strategy without any assurance of success, however the implementation of this strategy first initiated the information technology innovation. In Case 6 an opportunity or gap was identified in the software market for existing pharmacy practice software by the entrepreneurial business founder who left his employment as a pharmacist to start a software business. In Case 7 the two senior researchers established vision to utilise multimedia content as a health education option and despite mixed outcomes in terms of the research evaluation continued to move forward with the innovation and eventually establishing a social business enterprise on the basis of its IT innovation. In Case 8 the owner-manager of one organisation identified an opportunity to modify an existing software product that could be sold to ERP vendors and customers. In Case 9 the opportunity was identified to differentiate the organisation's approach to systems integration with its customers. As the innovation progressed, further commercial opportunities with its partner network were quickly identified.	C1.business-model-influence C4.business-domain-knowledge C4.marketing-strategy C6.opportunity C7.entrepreneurial C7.domain-experince C8.success C9.partner-network C9.customer-access
<u>Commercialise</u> The decision to innovate and the exploitation of opportunities were many cases driven by the opportunity for commercial gain or profit. Even though in Case 2 the innovation owner was not in the business of ICT production, the opportunity to commercialise influenced a decision later in the innovation to explore the possibilities. However the option was not taken up because profit margins were forecast to be limited. In Case 6 the software innovation eventually lead to a decision to commercialise the software via the creation of a new business. In Case 7 a new phase of innovation commenced around the establishment of a social business enterprise. In Case 8 the innovation's future success and ongoing development required the two stakeholder organisations formalise their commercial arrangements with a joint venture.	C2.commercialise-opportunity C5.commercialise-service C6.commercialsiation C7.social-business-enterprise C8.joint-venture
<u>Re-domain-technology</u> Arthur (2009) describes the process whereby a technology can be taken from use in another sector of the economy and repurposed or adapted for use in another. The terminology used is described as 're-domaining'.	C5.redomaining C9.gamification

Consolidated Theme	Within case instances
Whilst not prolific re-domaining was evident in Cases 5 and 9. In Case 5 LIDAR technology was repurposed from the mining and engineering sectors to map forestry assets. The re-domaining process was significantly influential in this innovation and the decision to move forward with development. In Case 9 the use of gamification theory was novel in the context of user adoption for enterprise social networking software, but arguably the concept was already in use across the ICT consumer sectors. However the use of gamification concepts for user adoption in the corporate context was key part of the decision to innovate in Case 9.	

5.2.2.3 Decisions in phases

Innovation decisions where not isolated one off events, decisions were made on an ongoing a possibly continuous basis, although they appear to be common around distinct phases or clusters of activity that vary from case to case. Incremental development models or minor variations of such dominate the general approach to development and innovation activity seen across all cases. There is also evidence of distinct phases or clusters of activity oriented towards specific objectives in all but a few cases. The phased and incremental approaches were also characterised (in most cases) by long cycles of innovation activity and experimental like outcomes aimed at managing the uncertainty of outcomes, and to provide justification for the next cycle or phase of innovation activity.

Table 5-4. Decisions in phases consolidated themes.

Consolidated Theme	Within case instances
<u>Incremental-development</u> Incremental development approaches were evident in all cases. In effect features and improvements were added incrementally to the innovation. Innovation decision making was continuous through this process, small and relatively minor decision were taken in respect to design, development, implantation and testing at each increment, but larger and more influential strategic decisions were often made at the end of phases or activity oriented toward specific innovation objectives. For example in Case 3 each iteration of a form was taken back and forth trough senior management and operational staff to determine the next stage of activity. In Cases 5 and 7 distinct decision making phases were planned or manufactured to allow for strategic decisions to be made about the innovation. Further decisions were made to redevelop software to mitigate various platform and equipment dependencies. Additional functionality was added in response to business requirements. Part of the development of this functionality was temporality outsourced to an external	C1.incremental-development C2.experimental C2.phased-development C2.testing-debugging C3.continuous-development C4.leveraging-initial-outcomes C4.incremental-improvments C4.testable-outputs C5.scaled-approach C6.experimental-development C7.phased-approach C8.dynamic-development C8.quality-reliability C9.development-challenges

Consolidated Theme	Within case instances
software developer. Case 5 used a distinct scaling up approach to the diffusion and improvement of its innovation.	
Long-time-frames Innovation activity was characterised by relative long time frames. This was evident in most cases if not implied in all but one (Case 9). The implications for decision making is that because innovation activity was ongoing, decisions were being continuously made through out the innovation lifecycle. A review of the within case inductive coding for Cases 2, 4 and 7 identified that codes were generated that supported long innovation cycle times present the original within-case analysis. However these codes were not emphasised but rather absorbed into the subsequent theme based codes generated for these cases. In comparison to other cases, Case 9 had spanned a relatively short time frame. However, innovation in Case 9 was in its infancy and the innovation owner indicated that the innovation was expected to continue to improve and develop over time.	C1.long-term-evolution C3.long-development-cycle C5.long-cycle-time C6.long-time-period C8.long-time-frame C9.short-time-frame
Dealing-with-uncertainty Innovation activity, particularly the opportunistically driven innovations appear to emphasise to role of uncertainty in decision-making. The risks associated with limited or incomplete information whilst acknowledged were actively managed in many cases. The adoption of phase and incremental development approaches is highly likely to be implicitly linked to uncertainties about the development outputs. Where formal phases were used per Cases 5 and 7 they were undertaken with the objective of assisting to manage some of the uncertainties associated with the innovations. In Case 9 uncertainties were evident but perceptive decisions were made about the nature and type of innovation activity to undertake.	C1.requirements-from-testing C4.managing-uncertainty C5.scaled-approach C7.experimental-development C8.joint-venture C8.quality-reliability C9.serendipity C9.uncertainty
Justify-initiatives The phased and incremental development approaches, whilst allowing for continuous decision making and dealing with uncertainty also allowed innovators and innovation stakeholders to justify the worth of initiatives and remove uncertainty where possible. This allowed the organisations and innovators to make decisions about moving on to the next phase. In Cases 2,3,6 and 8 the business owners (leadership roles) were involved in in the justification decision-making. In Cases 1 and 9 the respective core business missions of low cost and value adding justified the initiatives.	C1.business-model-influence C5.anticipated-benefits C5.unanticipated-benefits C7.evaluation C7.funding C7.institutional-organisational C9.core-business

5.2.3 Social structures

The previous section re-examined, and clustered and consolidated themes in the context the decision to innovate across all cases. Similarly, the role of social structure identified within cases was re-examined to consolidate and identify roles and actor archetypes that were present and influential in the decision to innovate.

Roles and actors identified within cases in Chapter 4 were filtered in terms of their influence upon innovation decision-making and then consolidated across all cases. Similar or related roles were grouped together and classified into higher-level archetype roles and actors and displayed in table 5-5.

Thirty-two roles and actors were interpreted as influencing innovation decisions across all cases. These social structures were clustered into nine archetypes – customer/users, developers, government, incubators, industry networks, innovation owner, leadership, research institutions and suppliers.

Table 5-5. Consolidated list of social structures influencing the decision to innovate

Role/actor archetype	**Within case instances**
Customer/User Individuals and organisations that utilise the outputs of the innovation, the IT artefacts, process, changes that are implemented. The term user and customer are used interchangeably with the term "customer" being more oriented towards the ICT-producing sector that tend to sell the outputs on a commercial basis. The presence of customer and users in innovation is somewhat inherent. In Case 2 sales staff assisted to determine the problem to solve as part of the innovation. In Case 4 the marketing department created the initial place branding strategy and vision. In Case 5 resource management specialists initiated the proposal to utilise LIDAR technology. In Case 7 remote indigenous populations determined the stories used for digital content. In Case 8 customers of the systems integration organisation pushed for a solution to document routing issues.	C2.Organisation 2a sales staff C4.Marketing department C5.Resource management specialists C7.Remote indigenous populations C8.Organisation 8b customers C8.BPO organisation
Developer Individuals and organisations that were involved in the business and technical changes. Includes software developers that designed and wrote code, information technology specialists that assembled or configured information technology artefacts, change managers who deployed and implemented change. In Cases 1,2,4, and 8 the developers made technical decisions about the approach to innovation. In Case 9 the developers were given an open opportunity to determine the nature and type of innovation that would proceed.	C1.In-house IT developers C2.Organisation 2b software developers C4.Internal IT specialists C8.The software developer C9.Software developers
Government State or federal government organisations. In Case 6 the public/government owned and operated health sector was influential in the innovation decision process.	C6.Public health sector

Role/actor archetype	Within case instances
Incubator An organisation providing facilities and resources for the innovator to develop and commercialise the design. Resources include equipment, work space and support staff with skills in business, finance and/or marketing. In Case 7 the incubator allowed the organisation to commercialise as a social business enterprise.	C7.Incubator
Industry Network Business networks of like-minded organisations formed around a specific IT platform or common business objective. Across cases this included other social structures such as suppliers, competitors and customers. In Case 7 healthcare organisations made decisions about what the research program would evaluate and test. In Case 8 the ERP business partner networks provided commercialisation options. In Case 9 Organisation 9 had access to a large business partner network that influenced the decision about what audience it would use to test its innovation.	C7.Healthcare organisations C8.ERP Partner network C9.Platform Partner network
Innovation Owner An individual and/or organisation that controlled and/or appropriated the commercial benefits of the innovation. The presence of an innovation owner is an inherent social structure involved in innovation activity and hence present across all cases. The innovation owner made innovation decisions in all cases.	C1.Organisation 1 C2.Organsiation 2a C2.Organsiation 2a C3.Organsiation 3 C4.Organsiation 4 C5.Organsiation 5 C5.Organsiation 6 C5.Organsiation 7 C8.Organisation 8a C8.Organisation 8b C8.Joint venture company C9.Organisation 9
Leadership Leadership is used in the social structure context of the cases to refer to an individual or group within an organisation responsible and actively providing guidance or direction to others in relation the business or the innovation objectives. In Cases 1, 2, 3 and 6 organisational management was responsible for the initial decision to commence innovation. In Case 5 the board of management made the final phase decision commence full scale rollout of the LIDAR data collection. In Case 7 two individuals founded the initial projects and formed Organisation 7, they were then responsible for guiding the projects through the early stages of innovation and on to the establishment of a social business enterprise.	C1.Organisation management C2.Organisation 2a business owners C3.Senior management team C5.Board of management C6.Business owner/founder C7.Organisation 7 founders C8.Business owner Organisation 8b
Research Institution Organisations where the primary business activity is research. Research institutions participated or influenced research and	C6.Academic research institution C7.Research program C7.Academic institutions

Role/actor archetype	Within case instances
development and in one cases provided administrative and financial support. In Cases 6 and 7 research institutions had influenced business administration decisions.	
<u>Supplier</u> An individual or organisation that provided goods and/or services as inputs into innovation activity. In some instances the supplier was also a developer in providing software design and development services. Suppliers also appeared in several industry network structures. In Case 9 the platform vendor had significant influence about nature and type of innovation.	C9.Platform vendor

5.2.4 Information technology artefacts

The previous section re-examined social structures in the context the decision to innovate across all cases. Similarly the role of information technology artefacts identified within cases was re-examined to consolidate and identify classes of information technology that were present and influential in the decision to innovate.

Information technology artefacts identified within cases in Chapter 4 were filtered in terms of their influence upon innovation decision-making and then consolidated across all cases. Similar or related information technologies where grouped into classes of information technology and presented in table 5-6.

Twenty-five information technology artefacts were interpreted as influencing innovation decisions across all cases. These artefacts were clustered into nine relatively generic classes of information technology artefact – applications, architecture, data, hardware, intellectual property, platforms, processes and services.

Table 5-6. Consolidated list of information technology artefacts influencing the decision to innovate.

IT Artefact archetype	Within case instances
<u>Application</u> Information technology products or services that focus on a specific function or solve specific business problems example would be a software products. The existing state or availability of software applications influenced innovation decisions and in several cases the opportunity to develop an application also came into consideration.	C1.Retail software C1.POS Equipment C1.Communication utility C2.PDA order entry software C3.Aquaculture production control software C4.Existing property management

IT Artefact archetype	Within case instances
In Cases 1,2, 3 and 8 existing applications were considered inadequate for the organisational needs. In Case 4 existing systems required automated workflow to integrate transactions. In Cases 6 and 9 opportunities to develop software applications where a key part of the innovation decision.	systems C4.Web site C6.Medication management software C6.Prototype software C8.Virtual printer software C8.Email C9.Rewards and recognition software module.
<u>Architecture</u> The combination, arrangement and assembly of related artefacts to allow the innovation or a component of the innovation to function. System architecture and design was considered during innovation decisions made in Case 1. Whilst the innovation occurred primarily around the POS software, the design and configuration of other IT dependencies was carefully considered an part of the decision making.	C1.System architecture
<u>Data</u> In the context of this study we take data as being pieces of information that have been collected, stored and processed in a digital form. Examples include numerical data, text and multimedia content. Data played an important role in Cases 5 and 7. In Case 5 initially and then at various stages in the project the multimedia content developed was important in facilitating further innovation. In Case 7 data collection was the initial objective for the innovation but it was only once the innovator had collected the initial round of LIDAR data that they realised its broad applicability to their business and further decisions were made about and in favour of extended innovation.	C5.LIDAR Data C7.Digital multimedia content
<u>Hardware</u> Physical information technology equipment and computing resources either acquired, built of assembled. Hardware artefacts provide an interface between virtual or logical artefacts and the physical world. Hardware artefacts are inherent in information technology innovation however their influence varies and in some cases hardware is not mentioned. Cases 2, 5 and 7 made explicit mention of the role of IT hardware in innovation decisions. In Case 2 the PDA equipment and barcode reader was not delivering the efficiencies that the business owner had expected, this problem was part of the overall design to undertake the new software innovation. In Case 5 the availability of LIDAR technology was a key driver for innovation. In Case 7 the use of multimedia kiosk terminals was the main initial decision and approach taken to deliver the multimedia content. In fact when the innovator conceptualised the innovation it was viewed in the context of the hardware and not the underlying system that would also make it possible.	C2.Sales Order PDAs+ C5.LIDAR technology C7.Kiosks
<u>Intellectual Property</u> Copyrights, patents and trademarks that create artefacts for the protection of invention and design.	C8.Intellectual property

IT Artefact archetype	Within case instances
In Case 8 the status of the intellectual property generated through the early stages of innovation was influential in the two organisations forming a joint venture to allow it to engage and innovate with larger scale clients.	
<u>Platform</u> Systems from which other systems and technologies can be developed from. They differs from application artefacts by virtue of their variety and scope for use and their support for creating new applications. In Case 1 the development of a database management system to collect and manage data was a key part of the design decision. In Case 2 the new sales order entry software was to be made compatible/integrated with the ERP platform. In Case 8 customer changes around ERP platforms and the lack of document routing functionality drove the decision to innovate. In Case 9 Organisation 9 developed their software application as a module to work with IBMs enterprise social media platform.	C1.Database Management Systems C2.Organisation 2a's ERP platform C8.ERPs C9.Enterprise social media platform
<u>Process</u> Information technology development activities, tasks, routines, methods and techniques used in innovation activity. Examples include but are not limited to software development methodologies, architectural designs, requirements management techniques, test plans, project management frameworks and change management tactics. In Case 1 the existing software development environment had been superseded or made partially obsolete by technology advancements and this was a key drive for change and innovation.	C1.Software Development Environment
<u>Service</u> Using resources to support innovation activity without ownership of the resources. Examples include but are not limited to contracting developers to write software, gaining access to data networks and hiring or leasing equipment. In Case 1 the initial constraints associated with wide area data network services influenced the approach to innovation. At a later stage when the constraints were eased and the service quality and availability improved this facilitated decisions to add new developments and improvements to the existing innovation. In Case 4 the availability of online booking services was a major driver and influence in requiring the innovation in itself.	C1.Wide Area Network C4.Online booking services

5.3 Research theme – innovation activity

5.3.1 Introduction

The following section examines data relating to innovation activity across all cases. The innovation literature emphasises the importance of collecting data about innovation activities, along with the linkages between innovation processes and sources of information, knowledge, technology and other resources.

For the purpose of this research innovation activity is defined as all the 'scientific, technological, organisational, financial and commercial steps, including investment in new knowledge' that facilitates the implementation of an innovation (OECD/Eurostat 2005, p. 18). The heuristic device developed in Chapter 2 reflects this definition of innovation activity and emphasises that activities include – research and experimental development; the acquisition of capital goods and services; the acquisition of external knowledge; and activities associated with implementation and deployment. The notion of design as an innovation activity is also encapsulated within development and implementation activities.

Results from within-case analysis in Chapter 4 pertaining to emerging themes, social structures and information technology artefacts were filtered for relevance to innovation activity and then re-examined for relationships across cases.

- Section 5.3.2 examines the emerging themes using a case ordered meta-matrix. A clustered thematic map is then presented to provide an overview of the themes present across cases. The consolidated themes are then described in the context of the relevant cases.
- Section 5.3.3 examines the social structures present across cases. Within case data was consolidated by grouping social structures into roles and actor archetypes and displaying the results in the context of relevant cases.
- Section 5.3.4 examines the information technology artefacts present across cases. With-in case data was consolidated and grouped into classes of information technology and displaying the results in the context of relevant cases.

5.3.2 Themes

Within case themes were identified in Chapter 4 through a process of inductive coding. Themes, associated codes, field notes and analytic memos where reviewed for any connection or relationship to innovation activity. The relevant themes were then identified in conjunction with the cases and a summary of memos relating to the innovation activity. A case ordered display is presented in table 5-7 that summarise the relevant themes and context.

Table 5-7. Case ordered display for themes relating to the innovation activity.

Case	Case Memos	Themes
1	Software was developed on a continuous improvement basis, adding functionality and fixing issues over a long time period. Prototyping methods were employed to allow the users to test new functions and concepts and further refine software requirements. Access to IT development knowledge and the ability to apply that knowledge was an important component of the innovation's success. Organisation 1 sourced information technology knowledge in-house. Although it did turn to external sourcing when adding new functionality around staff time and attendance/rostering. However there were issues understanding requirements when external development resources were used and new controls were needed to manage this aspect of the development. Emphasis was placed on collaboration with managers and users to establish system requirements. The users and managers drove most of the functional design, but there were a range of functions introduced from the IT team. The development team demonstrated a high degree of sympathy and respect for the information technology skills and capabilities of the end-users and this may have facilitated successful deployment. Requirements appear to have been better resolved at testing as opposed to requirements gathering sessions. The platforms that underpinned the original development were replaced in the market by new innovations. These changes had a significant influence on how development proceeded and subsequently evolved moving forward. Organisation 1 had developing and maintaining skills and retaining internal staff.	Incremental-development Continuous improvement Long term evolution Prototyping IT know-how Understanding-requirements Collaboration with managers and users. Requirements from testing Respected end-user IT capabilities Agency issues IT platform-changes IT market innovation IT dependencies Difficulty maintaining IT skills Challenge IT staff retention
2	Innovation in Case 2 involved a high degree of collaboration with a third party software development organisation. The relationship was highly interactive and based on trust. The collaborative relationship was a critical factor in the success of this innovation but it did not appear to be as effective from a software engineering efficiency perspective. However the developer cited the process as being very effective for delivering creative and innovative solutions. The incorporation and application of business knowledge, particularly of the business processes required to design an acceptable system was present in innovation activity. Ideas were tested within the system to determine the impact and effectiveness for specific requirements. There was also a need to integrate with commercially off the shelf software and equipment and the existing ERP system.	Supplier-collaboration Requirements gathering Trust Incremental-development approach Knowledge of IT development Business knowledge Experimentation Use of IT capital goods Phased development Seller-customer relationship Customer-technology relationship

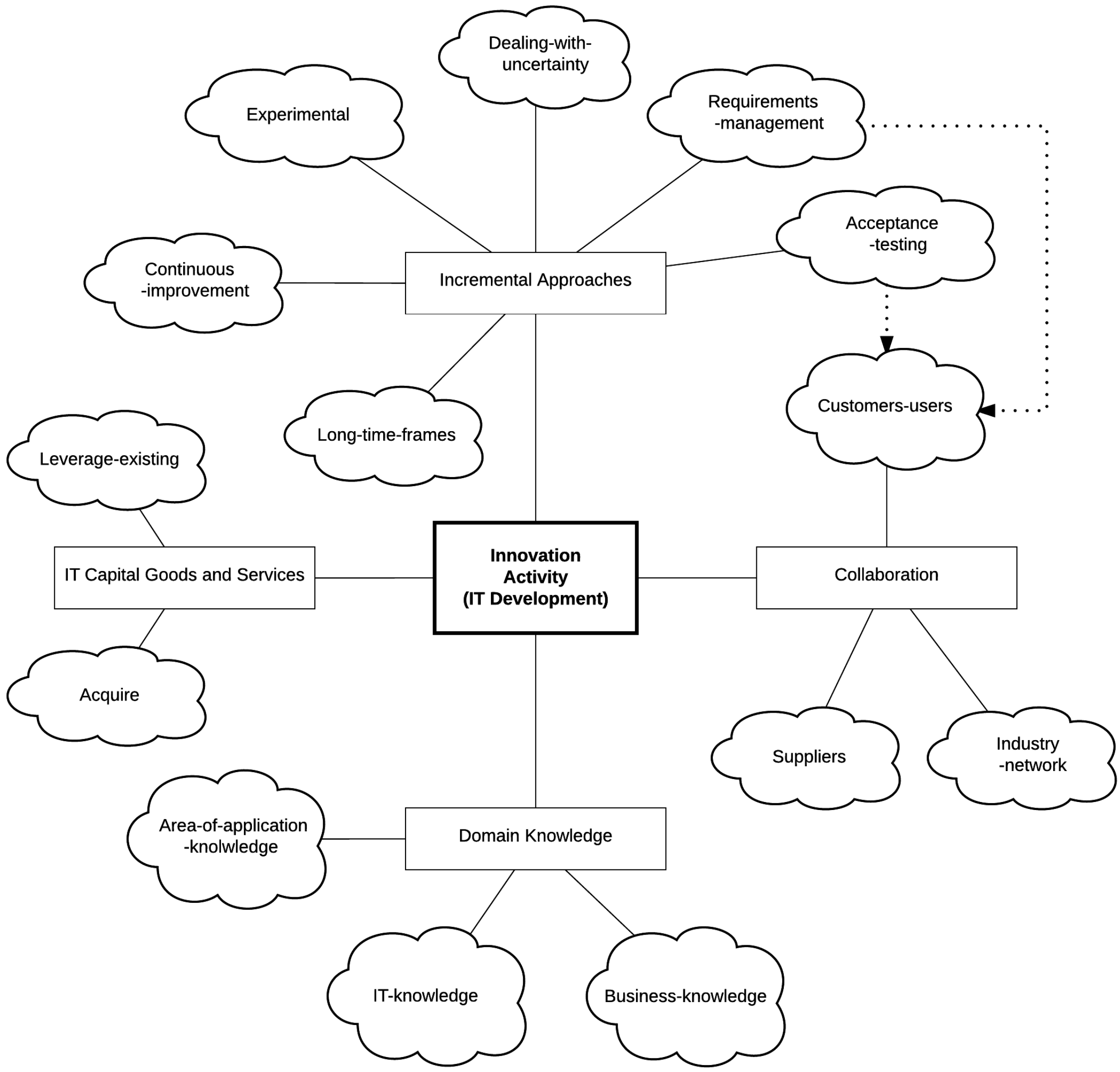
Case	Case Memos	Themes
	Development activity phased and incremental. Each phase appeared to been set high level goals or objectives from which a series of incremental plan, design, code and test sequences were performed in close collaboration with stakeholders.	
3	Development activity was concerned with solving problems associated with the collection, storage, processing and distribution of information. An external third party undertook information technology development. A deliberate formal requirements process was used to elicit requirements from stakeholders and filter them to the developer. The requirements gathering process involved interaction between management, operational (farm) stakeholders and the developer and that was facilitated by an internal business analyst. Development outputs took a long time to complete.	<u>Interactive-development</u> Solving information handling problems Outsourced development Requirements process Long development cycle Continuous-development
4	An iterative process was employed to refine the design and output of innovation activities. Specific mechanisms were employed to address uncertainties in the development process and outcomes. The outputs of incremental innovation activity produced outputs that could be tested in business operations (by the internal customer). Collaboration between internal customers and external suppliers with respect to the business requirements or fitness for purpose (quality). Internal customers and suppliers were involved in the testing process. Operational and technical knowledge was sourced internal customers and external suppliers to progress the innovation. Existing information technology assets and capabilities were used to progress innovation. New information technology assets and capabilities were introduced to progress innovation. Specific information technology assets were being used for multiple purposes or application. The middleware integration technology provided a capability to automate and simplify inventory management across a range of systems and related businesses and thus became a source of continuous innovation.	<u>Incremental-evolutionary- approach</u> Continuous improvement Managing uncertainty Testable outputs <u>Collaboration-users-suppliers</u> Requirements collaboration Testing collaboration Sources of technical knowledge <u>Merging-using-IT-capabilities.</u> Leveraging existing IT capabilities Introduction of new IT capabilities Role of IT platforms
5	Development progressed with increasing scale. Technology was taken from use in another sector of the economy and repurposed or adapted for use in another. There was collaboration with suppliers, competitors, academic and research institutions. Development spaned a long period of time. The incorporation and application of information technology techniques and methods to engineer the system. Access, incorporation and integration of commercially off	<u>Experimental-development</u> Scaled approach Re-domaining Collaboration Long cycle-time <u>Capability-building</u> IT knowledge

Case	Case Memos	Themes
	the shelf software, operating platforms and equipment. New routines were developed for information handling. A production model or chain emerged for processing data. Large amounts of data were processed. Data assets were utilised for multiple applications and purposes.	Technology acquisition Information management <u>Data</u> Data production model Volume Multiple applications
6	An essential component of the innovation throughout its lifecycle was the domain knowledge the founder of Organisation 6 had gained through his experience as a clinical pharmacist working in the public health sector. Development activity was concerned with solving a problem (associated with the collection, storage, processing and distribution of information). An end-user software development tool was used to progress development. A commercial opportunity was identified. External professional information technology development knowledge was sourced/utilised. An external and commercial IT development platform or framework was utilised. External business administration skills were sourced/utilised. A number of barriers were encountered during the commercialisation process – arguments about intellectual property rights with the founder's previous employer; mistakes in the original software design and difficulty marketing software to the health sector.	<u>Experimental-development</u> Domain Knowledge Solve-a-problem End-user development platform Mistakes <u>Commercial-collaboration</u> Exploit-an-Opportunity Commercial IT know-how Commercial IT platform Business know-how Barriers Product evolution
7	The creative leadership of the founding researchers drove innovation in Case 7. The same leadership prevailed though innovation activity recognising problems that needed to be solved throughout the innovation lifecycle. Leadership in Case 5 also had significant experience dealing with indigenous health issues, health promotion and education. This experience was successfully applied to the digital sphere taking key learning's from the participatory model that had been developed using forum theatre in similar contexts. Development in Case 5 was distinctly research driven and experimental in design. The development initially was split into two distinct phases, then later three with varying levels of design to meet high-level program objectives. Development was centred upon three different types of activity. In the initial phase development focused on the development of IT infrastructure and the creation of digital content. IT infrastructure development was initially concerned with the acquisition of hardware and software to operate the kiosk but in later stages this extended to having a third party design and develop a customised hardware and software platform to manage and deploy interactive multimedia content.	<u>Leadership</u> Entrepreneurial Domain experience <u>Experimental-development</u> Phased approach Content development IT infrastructure development IT capability development Evaluation <u>Collaboration</u> Customer collaboration Supplier collaboration

Case	Case Memos	Themes
	Formal evaluation processes were undertaken to examine the project outcomes and this information informed the requirements for the next phase. There was a high degree of interaction and collaboration undertaken between users or community stakeholders (customers) and the development teams in relation to the digital content. There was also a high degree of supplier collaboration in the development of IT infrastructure. Organisation 7 had sourced the expertise for kiosk and content management system development from external parties throughout the development lifecycle.	
8	The development was driven by requirements that were created dynamically from testing. Specialised knowledge of software design and development were used to improve or resolve issues from tests. Software testing focused on resolving software defects and alignment its fitness for purpose with the use cases. Testing was undertaken by users/customers of the software. Testing was a collaborative venture with customers. A formal organisation arrangement was made between the developer and systems integrator. Ecosystems of users and systems integrators focused on particular software solutions were used to market and diffuse the product. Development and diffusion occurred over a long time frame.	Testing Dynamic development Software engineering knowledge Quality and reliability issues Customer testing Collaboration Customer testing Joint venture Market-diffusion Software ecosystems
9	The software developed as part of the innovation in Case 9 was adaptive and incremental and whilst it was initially informal it followed the general principles of an agile development process. Innovation activity in Case 5 was characterised by informal planning, customer collaboration and short development/release time frames. Two important knowledge based processes also appeared to be present within the innovation activity (1) the application of game mechanics to software functionality; and (2) the evolution and improvement of software engineering and development capabilities Challenges were associated with resourcing and running development activity. Particular challenges in relation to the organisation of its resources so they were focused on development and not distracted by operational support problems and the adoption new development techniques to assist with the speed and efficiency required to meet the demands of it customers (and potential customers). Interaction with customers to test and provide feedback on the software features and reliability. Access to a network of platform users and would be customers. Access to third party solution integrators and resellers (partner networks) associated with the same platform.	Agile-development Gamification Software development capabilities Customer collaboration Operational challenges Development challenges Short time-frames Platform-ecosystem Customer access Partner network

Themes identified in table 5-7 where further analysed and consolidated across cases. Fourteen themes emerged that were clustered into four high level organising themes, that were interpreted as relating to innovation activity. A thematic map provides an overview consolidated and clustered themes in figure 5-2.

Figure 5-2. Thematic map for consolidated and clustered themes for innovation activity.



Themes are further elaborated in the following sections describing the clustered organising theme along with the consolidated and related themes with their within cases instances.

5.3.2.1 Incremental approaches

Incremental development approaches dominated innovation activity associated with design, development and implementation of information technology innovations across all cases. Incremental methods were described in section 5.2.2.3 in the context of innovation decision-making, but they were equally profound in the context of innovation activity. The key themes associated with the incremental development approaches used across cases where (a) the use of experimental techniques to develop and test solutions; its use as a mechanism for dealing with uncertainty; the continuous nature of development and improvement; the relatively long innovation cycle times; and the importance of requirements management and user acceptance testing during and for development.

Table 5-8. Incremental approaches consolidated themes.

Consolidated Theme	**Within case instances**
Experimental Experimental techniques were employed as part of the incremental development approaches used in several cases in order to verify and validate designs against requirements. Cases 1, 2 and 6 employed prototyping methods to build working solutions to test with customer/users. For Case 6 this may have been unintentional at the outset, but it was viewed longer term as an experiment where design mistakes we used to define future development. In Cases 4 and 5 the scope of development and deployment was scaled to allow elements of the design to be tested in a real-world context. For example in Case 5 the scope of deployment was gradually scaled up starting with a small scale experiment with LIDAR technology, incrementally building up the scope before full scale deployment. Case 7 conducted formal research and evaluation via a social experiment that investigates the effectiveness of digital multimedia content for health education outcomes.	C1.prototyping C2.experimental C4.leveraging-initial-outcomes C5.scaled-approach C6.end-user-dev-platform C6.mistakes C7.phased-approach
Dealing-with-uncertainty One of the challenges for development that was cited by participants within cases was knowing exactly what the customer or user actually wanted. Requirements information was often incomplete and some stakeholders found it difficult to articulate what was acceptable without seeing what was possible. Uncertainty was also manifest for innovations that sought to design solutions for future customers i.e. developers could not be completely certain if their designs would meet the needs of potential customers. In Case 1 users were described as not being particularly IT savvy and that they found it difficult to provide requirements information because they did not understand what was possible. Incremental steps	C1.decisions-in-phases C2.phased-development C4.uncertain-outcomes C4.undetermined-requirements C5.scaled-approach C9.serendipity C9.uncertainty

Consolidated Theme	Within case instances
allowed developers to work with users and increase the amount of information available to reduce uncertainty. In Case 2 uncertainty about the scope was managed in phases, but it took its toll on development time frames. In Case 4 the initial phase was highly speculative and the organisations response to the uncertainty was to hold off on full scale development. Similarly the innovation owner in Case 5 scaled the approach to LIDAR deployment. In Case 9 developers had experience facilitating user adoption of the enterprise social media platform, but still had to deal with the uncertainty of whether customers would accept the innovation.	
<u>Continuous-improvement</u> Across cases innovation activity involved the continuous incremental improvement of information technology innovations. An in-depth review of each case reveals there are no examples in any case under study of an innovation having being developed and not incrementally improved as it diffused into operations. However evidence was strongest from the themes emerging from Cases 1,4,6 and 8 In Case 1 software was developed and improved through the entire lifecycle of the innovation. Improvements ranged from small changes to entire software rewrites. In Case 4 integration work was gradually automated and refined. In Case 6 the software innovation evolved from a clinical pharmacy focus into a platform that supported medication management, medication knowledge management, electronic referrals and integration of patient diagnostic information from other health applications. In Case 8 continuous testing and feedback from customers improved the quality and reliability of the innovation and allowed new document routing methods to be supported e.g. XML and database routing.	C1.continuious-improvement C4.incremental-improvments C6.product-evolution C8.dynamic-development
<u>Long-time-frames</u> With the exception of Case 9 innovation activity extended across relatively long periods of time. A review of the within case inductive coding for Cases 2, 4 and 7 identified that codes were generated that supported long innovation cycle times present the original within-case analysis. However these codes were not emphasised but rather absorbed into the subsequent theme based codes generated for these cases. For Cases 1,3,5,6,7 and 8 innovation activity spanned more than 10 years. For Cases 2 and 4 it was more than three years. In Case 9 the innovation was in its infancy and the innovation owner was forecasting an extended lifecycle for the innovation as well.	C1.long-term-evolution C3.long-development-cycle C5.long-cycle-time C6.long-time-period C8.long-time-frame C9.short-time-frame
<u>Requirements-management</u> Accounts of formal and informal methods for capturing customer/user needs and expectations were present across many cases. The process is more notable in the consolidated themes of the non-ICT sector organisations however inductive codes were generated in ICT sector innovators but absorbed into themes concerned with customer and collaboration. Data relating to customer collaboration in the case of	C1.agency-issues C1.collaboration-managers-users C1.requirements-from-testing C1.respected-end-user-IT-capabilities C2.requirements-gathering

Consolidated Theme	**Within case instances**
ICT sector innovators and supplier collaboration in the case of non-ICT sector innovators is an important consideration for requirements management because many of the collaboration processes were focused on communication of requirements. User and manager collaboration around requirements was a significant feature of innovation activity in Case 1. When the innovator outsourced some elements of development issues arose with the overheads required to maintain a formal collaborative requirements process. In Case 2 the requirements process was initially informal, relying on trust and collaboration with supplier. At a later stage a formal process was introduced to attempt to control scope and better define the needs of the business owners in relation to innovation improvements. In Case 3 there was a formal requirements process, but longer term this process was shown to have been incomplete in terms of understanding the needs of some operational stakeholders. This had implications for user acceptance and diffusion of the innovation within the organisation. Case 4 was similar to Case 2 in that requirements processes were initially quite informal, but they matured into formal processes in an attempt to improve the development outcomes. Further decisions were made to redevelop software to mitigate various platform and equipment dependencies. Additional functionality was added in response. The requirements process was also linked to acceptance testing in two ways – (1) developers would return to customers/users to test that the requirements and expectations had been met; and (2) tests with customers/users produced new or updated understandings of the requirements. The latter was particularly pervasive Cases 1 and 8 where most requirements were generated from acceptance testing.	C3.requirements-process C4.requirements-collaboration
<u>Acceptance-testing</u> Formal and informal processes where employed across many cases to evaluate the quality of design and development to ensure it was fit for purpose and/or to shape a response to issues and defects. As described in the discussion relating to requirements management, acceptance testing is implicitly linked to requirements and absorbed within themes associated with customer/user and supplier collaboration. Across cases a variety of objectives were evident in relation to the role of testing in innovation activity. In Case 1 testing was used to ascertain the requirements. In Case 2 testing focused in software debugging and for useability design for customers and sales staff. In Case 4 testing was used to verify reliability of workflows. In Case 8 testing focused on quality and reliability (debugging) and similar as in Case 1, testing also drove the requirements process.	C1.requirements-from-testing C2.testing-debugging C4.testing C8.customer-testing C8.quality-reliability

5.3.2.2 Collaboration

Collaborative work practices were pervasive for innovation activity across all cases. Whilst there were many levels and types of interaction, the dominant collaboration relationships were between developers and customers or users. Where supply relationships were formed this relationship was between internal developers, project managers or business analysis and the suppliers. Industry networks i.e. loosely coupled organisations of competitors and/or organisations with similar businesses activities also played a significant role in innovation activity with several case studies.

The notion of collaboration in this descriptive cross case theme is centred on identifying relationships. However during the analysis process it became apparent that collaboration processes were linked to many other innovation activities present in the clustered themes. These links have been highlighted and described within those themes in conjunction with the following summary.

Table 5-9. Collaboration consolidated themes.

Consolidated Theme	**Within case instances**
Customers-users Interactions with customers and users describe innovation activities performed between stakeholders that utilise the outputs of the innovation. The distinction between customer and users is more one of a customer being a user external to the innovating organisation and in a commercial relationship with that organisation to use the software. Alternatively users can be considered internal customers of the innovation. Customers and user collaboration was present in all cases though not implicitly declared in Cases 5 and 6. In Case 1 inductive codes for user and manager collaboration were generated but absorbed into the incremental development approach themes of requirements management and acceptance testing. In Case 2 collaboration was identified between customers of the innovator and sales staff who where internal users. In Case 4 there was significant customer involvement in requirements management and testing. In Case 7 customers played a major role in the production of digital content that was used for health education across different communities. In Case 8 several customers were used to test and provide feedback on the development of software for document routing. In Case 9, once a basic product was put to the market it was refined and improved through formal a customer user group.	C2.customer-tech-relationship C2.seller-customer-relationship C4.customer-involvment C4.testing C7.content-development C7.customer-collaboration C8.customer-testing C9.customer-collaboration

Consolidated Theme	**Within case instances**
Suppliers Interactions with suppliers describe innovation activities that generally brought resources to innovation activity. Supplier collaboration was also an alternative or proxy for developer-user collaboration when development tasks were outsourced. Whilst the notion can equally apply to feedback provided by an innovator to a supplier of a turnkey platform or application used in the innovation process this was rare and only identified in Case 4. In Case 1 there was a brief collaborative relationship with a software developer but it was dissolved following difficulties with costs and timelines associated with the overheads managing requirements. In Case 2 a close collaborative relationship persisted with an external developer throughout the innovation lifecycle. In Case 4 technical knowledge was sought and transferred from the developer of an integration platform. In Case 6 a commercial development framework from a supplier was transferred and used to progress development. The process was collaborative rather than one of simple supply. In Case 7 several suppliers were utilised in a collaborative manner to assemble and configure multimedia kiosks and software platforms to support digital media playback. In Case 8 a long-standing collaborative relationship persisted between two organisations and they ultimately formed a joint venture business to progress the innovation through global diffusion.	C1.agency-issues C2.requirements-gathering C2.trust C3.outsourced-development C4.technical-knowledge-suppliers C6.commercial-it-platform C7.supplier-collaboration C8.joint-venture
Industry-networks Industry networks are defined in the context of this research as loosely coupled organisations of competitors and/or organisations with similar or related businesses activities. Industry network collaboration was not as pervasive across cases, but it was significant contributor to innovation activity is the cases where it was apparent. In Case 5 the innovator participated in remote sensing interest group and ultimately became a major facilitator and promoter of applied research in LIDAR technology amongst industry and academic research groups. In Cases 8 and 9 both innovators had strong links with partner networks and they collaborated with peers within these groups to distribute, diffuse and promote awareness of their innovations.	C5.collaboration C8.software-ecosystems C9.partner-network

5.3.2.3 IT capital goods and services

Information technology capital goods and services were acquired and maintained in most cases during the course of innovation activity. In the context of this research, the definition of IT capital goods has been adapted from Baetjer (1997) and defined as commercially available finished IT goods that embodied the knowledge of productive information handling process within in software, hardware, and/or architecture. Similarly IT services are the same but the supplier orchestrates or makes available the IT capital goods and the innovator does not exercise any ownership of the productive processes.

Table 5-10. IT capital goods and services consolidated themes.

Consolidated Theme	**Within case instances**
Acquire The acquisition of IT capital goods and services was implicit across many cases but not discussed or described in detailed within all cases (see section **Error! Reference source not found.** IT Artefacts). In Case 2 tablet computers and server infrastructure was acquired as part of the innovation. In Case 4 middleware infrastructure and web server hosting services were acquired to enable the innovation. In Case 5 LIDAR technology was accessed as a service. In Case 7 multimedia kiosks and content management software was acquired to distribute and play back multimedia content. Inductive codes were generated for Cases 1 and 3 describing the acquisition of infrastructure to support innovation.	C2.IT-capital-goods C4.IT-capital-goods-services C5.technology-aquisition C7.IT-infrastructure-development
Leverage existing Innovators leveraged pre-existing investments in IT capital goods and services, but similarly did not describe them in detail in the interview transcripts. In Case 4 the innovator describes extensive use of existing IT platforms and systems to effect the innovation. Inductive codes were generated for Cases 3 and 5 describing pre-existing IT capital goods being utilised to facilitate the innovation.	C4.role-of-platform

5.3.2.4 Domain knowledge

The acquisition and use of knowledge was a significant part of innovation activity across all cases. Three areas of knowledge appeared important for information technology innovation: IT knowledge (the knowledge of how to design, develop, assemble, and implement information technology); area of application knowledge (knowledge of the business area or domain where the innovation was to be applied); and business knowledge (knowledge of how to administer business in terms of finance, legal and governance).

Table 5-11. Domain knowledge consolidated themes.

Consolidated Theme	**Within case instances**
<u>IT-knowledge</u> In the context of this research IT knowledge pertains to understanding and knowledge of practises for the design, development, assembly and implementation of information technologies. The presence and importance of IT knowledge for innovation activity was not unexpected. It was evident in all cases but not described explicitly in detail in Case 3 outside of inductive coding relating to the outscoring of IT knowledge for development. In Cases 1 and 4 internal development resources provided most of the IT knowledge with some tasks outsourced where knowledge was required. In Case 2 IT knowledge was predominately sourced through the supplier/developer, but at latter stages some IT knowledge was acquired and vested with an internal resource In Case 5 most IT knowledge was acquired by the innovator with possibly the exception of knowledge about the operation of LIDAR data collection equipment. In Case 6 the founder had good end-user development skills, but ultimately turned to external commercial knowledge sources to develop the innovation. In Case 7 IT knowledge was initially completely outsourced, but issues with IT knowledge eventually saw the innovator acquire resources that were capable of absorbing the required internal knowledge to continue with more advanced innovation. In Case 8 IT development knowledge was predominately vested with the original software developer, although the innovator maintained some IT integration knowledge. In Case 9 the innovator possessed advanced software development skills and resources.	C1.IT-know-how C1.IT-staff-retention C2.IT-development-knowledge C4.existing-capabilities C4.technical-knowledge-suppliers C5.IT-knowlege C6.commercial-it-knowhow C7.it-capability-development C8.software-eng-knowledge C9.software-development-capability
<u>Area-of-application-knowledge</u> Knowledge of the business area where the innovation was to be applied was also significant for several cases. In Case 2 knowledge of the customer interaction and sales process was important in designing the software. In Case 4 marketing knowledge and knowledge of how it could be applied to the business and with information technology was a driving component of innovation activity. In Case 5 the key stakeholder driving innovation had substantial experience managing forest resource information and had extensive experience in the industry. In Case 6 knowledge and experience of clinical pharmacy practise in the hospital setting allowed for the development of software to support those practices. In Case 7 leadership had significant experience dealing with indigenous health issues, health promotion and education. In particular knowledge of participatory education methods such as forum theatre was used in innovation activity. In Case 9 understanding of the enterprise social media platform and the issues associated with user adoption lead the developers on a quest	C2.Business-knowledge C4.business-domain-knowledge C4.marketing-strategy C5.information-management C6.domain-knowledge C7.domain-experince C9.core-business C9.gamification

Consolidated Theme	Within case instances
to develop knowledge about the application of gamification theory. Further decisions were made to redevelop software to mitigate various platform and equipment dependencies. Additional functionality was added in response.	
<u>Business-knowledge</u> Knowledge of how to administer business in terms of finance, legal and governance was identified in three cases. In Cases 6 and 9 the knowledge was considered initially lacking and ultimately, once acquired, important for the success of the innovation. In Case 8 understanding how to structure the business, contracts and intellectual property was important a latter stages of innovation, in particular when dealing with larger customers.	C6.business-admin-knowhow C8.joint-venture C9.business-capabilities

5.3.3 Social structures

The previous section re-examined, and clustered and consolidated themes in the context the innovation activity across all cases. Similarly the role of social structure identified within cases was re-examined to consolidate and identify roles and actor archetypes that were present and related to innovation activity.

Roles and actors identified within cases in Chapter 4 were filtered in terms of their influence for innovation activity and then consolidated across all cases. Similar or related roles were grouped together and classified into higher-level archetype roles and actors and displayed in table 5-12.

Sixty-seven roles and actors were interpreted as relating to innovation activity across all cases. These social structures were clustered into nine archetypes – customer/users, developers, government, incubators, industry networks, innovation owner, leadership, research institutions and suppliers.

Table 5-12. Consolidated list of social structures influencing innovation activity.

Role/actor archetype	Within case instances
<u>Customer/User</u> Individuals and organisations that utilise the outputs of the innovation, the IT artefacts, process, changes that are implemented. The term user and customer are used interchangeably with the term “customer” being oriented towards the ICT-producing sector that tend to sell the outputs on a commercial basis. The presence of customer and users in innovation is somewhat inherent.	C1.Store managers C1.Users C2.Organisation 2a sales staff C2.Organisation 2a’s customers C3.Operational staff C4.Marketing department

Role/actor archetype	**Within case instances**
Due to the collaborative nature of development and the interaction between developers and customers/users for requirements gathering and testing, customer/user influence was pervasive in innovation activity across all cases. Case 1 is an excellent example of the influence that users had on assisting developer to understand the business requirements. User in Case 1 also assist developers select and implement user interface designs that would work in the organisational context. In Case 7 users were included in the process of designing and providing content for the multimedia stories used for community health education. In Case 8 customers were used extensively to test the software for quality and reliability.	C4.Internal business customers (users) C5.Resource management specialists C5.Operational staff C6.Hospital clinical pharmacy practices C6.Clinical pharmacists C7.Remote indigenous populations C8.Organisation 8b customers C8.BPO organisation C9.Users
<u>Developers</u> Individuals and organisations that were involved in the business and technical changes. Includes software developers that designed and wrote code, information technology specialists that assembled or configured information technology artefacts, change managers who deployed and implemented change. By definition the developer role would be expected to be influential in innovation activity across all cases. In some cases developers were internal employees and they performed most development tasks (Cases 1, 4, 5, 9) in other cases the role was outsourced (Cases 2 (initially), 3, 8) or hybrid where an internal business analyst type roll would facilitate requirements specifications and testing with an external developer (Cases 2 (later), 6, 7).	C1.In-house IT developers C2.Organisation 2a IT specialist C3.Business analyst/project manager C4.Internal IT specialists C5.Internal IT specialists C5.Internal spatial information specialists C5.Biometric modelling specialists C6.Business owner/founder C7.Organisation 7 technical manager C8.The software developer C9.Software developers
<u>Government</u> State or federal government organisations. In Case 6 the public/government owned and operated health sector was the initial context for innovation activity.	C6.Public health sector
<u>Incubator</u> An organisation providing facilities and resources for the innovator to develop and commercialise the design. Resources include equipment, workspace and support staff with skills in business, finance and/or marketing. Incubator style facilitator organisations were influential in Cases 6 and 7. For Case 6 the incubator provided business administration, governance and marketing support to get the innovation underway. In Case 7 the incubator was involved later in the innovation, and facilitated the innovators transition to a social business enterprise.	C6.Incubator business C7.Incubator
<u>Industry Network</u> Business networks of like-minded organisations formed around a specific IT platform or common business objective. Across cases this included other social structures such as suppliers, competitors and customers. Business networks were influential in a number of cases. In Case 5 like-minded industry organisations shared knowledge about LIDAR technology implementation.	C5."Like minded" industry organisations C7.Healthcare organisations C7.Health practitioners C8.ERP Partner network C9.Gamification experts C9.Platform Partner network

Role/actor archetype	Within case instances
In Case 7 healthcare organisations were important stakeholders and partial funders of the research and development activities. Health practitioners in the communities also participated in evaluation of the research. In Cases 8 and 9 partner networks associated with software platforms that the innovators worked with were important for diffusion and distribution of the innovations.	C9.Software distributors
<u>Innovation Owner</u> An individual and/or organisation that controlled and/or appropriated the commercial benefits of the innovation. The presence of an innovation owner is an inherent social structure involved in innovation activity and hence present across all cases. Innovation owners are implicitly linked to all innovations, however they also played an active role innovation activity. There was no case of an innovation owner not being involved in innovation activities. The only case where there was some degree or separation being the owner and involvement in activity would have been in Case 7. However the organisation in Case 7 was relatively large and whilst the innovation owners would be arguably the organisation's board, the board had delegated responsibility for progressing the innovation to key management personnel.	C1.Organisation 1 C2.Organisation 2a C3.Organisation 3 C4.Organisation 4 C5.Organisation 5 C6.Organisation 6 C7.Organisation 7 C8.Organisation 8a C8.Organisation 8b C8.Joint venture company C9.Organsiation 9
<u>Leadership</u> Leadership is used in the social structure context of the cases to refer to an individual or group within an organisation responsible and actively providing guidance or direction to others in relation the business or the innovation objectives. In Case 1 organisational management pushed the innovation at all stages. In Case 2 the business owners were heavily involved in higher level acceptance testing and requirements specification. In Case 3 senior leadership provided ongoing direction at the beginning of each software iteration. In Case 6 the owner and founder provided close and detailed specification of requirements and the high level objectives for commercialisation. The owner and founder also took on the developer role in the initial phase of innovation. In Case 7 two individuals founded the initial projects and formed Organisation 7, they were then responsible for guiding the projects through the early stages of innovation and on to the establishment of a social business enterprise. In Case 8 the business owner of the system integration organisation facilitated and guided the innovation through all phases. The business owner largely motivated the software developer to improve his software product.	C1.Organisation management C2.Organisation 2a business owners C3.Senior management team C6.Business owner/founder C7.Organisation 7 founders C8.Business owner Organisation 8b
<u>Research Institution</u> Organisations where the primary business activity is research. Research institutions participated or influenced research and development and in one cases provided administrative and financial support. In Case 5 academic and research institutions developed an interest in	C5.Academic and research institutions C6.Academic research institution C7.Research program C7.Academic institutions

Role/actor archetype	Within case instances
the application of LIDAR technology where the organisation also required traditional research and development tasks to be performed around different aspect of its deployment and use. In Case 6 in the initial stages an academic research project had worked on the original prototype that was eventually seen as a mistake and abandoned. In Case 7 innovation was born out of a research program operating within an academic and research institution.	
Supplier An individual or organisation that provided goods and/or services as inputs into innovation activity. In some instances the supplier was also a developer in providing software design and development services. Suppliers also appeared in several industry network structures. At some stage suppliers were involved in all cases, predominately in development type tasks or for the acquisition of capital goods and services. In Case 8 the developer whilst initially a supplier eventually became a partner and innovation owner.	C1.External software developers C2.Organisation 2b C2.Organisation 2b software developers C3.External software engineer C4.External software vendor (suppliers) C5.External LIDAR data collection services C6.Software development business C7.Multimedia developers C7.Kiosk/IT Partners C9.Platform vendor

5.3.4 Information technology artefacts

The previous section re-examined social structures in the context of innovation activity across all cases. Similarly the role of information technology artefacts identified within cases was re-examined to consolidate and identify classes of information technology that were present and influential for innovation activity.

Information technology artefacts identified within cases in Chapter 4 were filtered in terms of their relationship to innovation activity and then consolidated across all cases. Similar or related information technologies where grouped into classes of information technology and presented in table 5-13.

Sixty-two information technology artefacts were interpreted relating to innovation activity across all cases. These artefacts were clustered into nine relatively generic classes of information technology artefact – applications, architecture, data, hardware, intellectual property, platforms, processes and services.

Table 5-13. Consolidated list of information technology artefacts influencing innovation activity.

IT Artefact archetype	**Within case instances**
<u>Application</u> Information technology products or services that focus on a specific function or solve specific business problems example would be a software products. Software applications were pervasive across innovation activity in all cases except Case 5.	C1.Retail software C1.Communication utility C2.Mobile sales ordering software C3.Aquaculture production control software C3.Microsoft Excel C4.Existing property management systems C6.Medication management software C6.Prototype software C7.Mobile applications C8.Virtual printer software C8.Email C8.Fax C9.Rewards and recognition software module.
<u>Architecture</u> The combination, arrangement and assembly of related artefacts to allow the innovation or a component of the innovation to function. Approaches to the design and assembly of information technology components were influential in most cases. In Cases 1,2 and 3 systems architecture i.e. the assembly of software libraries, database platforms and related hardware and operating systems were part of the overall innovation. In Case 4 systems architecture was also important, but the innovator also developed data models and associated infrastructure to support their use and deployment for integration. In Case 5 systems architecture appeared complex and a data handling processes that formed important component of the innovation needed to be assembled to form the overall innovation. In Case 7 the innovation was a combination of kiosk hardware, content management software and digital multimedia content.	C1.System architecture C2.System architecture C3.System architecture C4.Data models C4.System architecture C5.Data models C5.System architecture C7.System architecture
<u>Data</u> In the context of this study we take data as being pieces of information that have been collected, stored and processed in a digital form. Examples include numerical data, text and multimedia content. Data was an integral part of innovation activity for Cases 2, 3, 5, and 7. In Case 2 sales data was integrated into an expert system to analyse seller and customer behaviours using the sales ordering software innovation. In Case 3 farm production data was the driver for development requirements. In Case 5 LIDAR data was used to develop new visualisation and decision-making applications.	C2.Sales data C3.Farm production data C5.LIDAR Data C7.Digital multimedia content

In Case 7 digital multimedia content was developed and evaluated for health education outcomes.	
<u>Hardware</u> Physical information technology equipment and computing resources either acquired, built of assembled. Hardware artefacts provide an interface between virtual or logical artefacts and the physical world. Hardware artefacts are inherent in information technology innovation however their influence varies and in some cases hardware is not mentioned. Information technology hardware was present in most innovations but identified as influential in innovation activity for Cases 1, 2, 5 and 7. In Case 1 POS equipment was acquired and configured as part of the innovation deployment. In Case 2 tablet computers were acquired and configured as part of the innovation deployment. In Case 5 LIDAR technology was utilised to collect data for forest resource management. In Case 7 kiosks and server computing infrastructure were acquired and configured as part of the innovation deployment.	C1.POS Equipment C2.Tablet computers C5.LIDAR technology C7.Kiosks C7.Computing Infrastructure
<u>Intellectual Property</u> Copyrights, patents and trademarks that create artefacts for the protection of invention and design. In Case 6 intellectual property issues needed to be taken into consideration when deigning the software innovation. In Case 8 the status of the intellectual property generated through the early stages of innovation was influential in the two organisations forming a joint venture to allow it to engage and innovate with larger scale clients.	C6.Intellectual property C8.Intellectual property
<u>Platform</u> Systems from which other systems and technologies can be developed from. They differ from application artefacts by virtue of their variety and scope for use and their support for creating new applications. The role and influence of software platforms in innovation activity across cases was substantial. In all instances outside of Case 6 platforms underpinned the innovation development. Possibly the most influential platform example is that of Case 9 where the enterprise social media platform was the basis for enabling the innovation and innovation activity involved the development of software that was effectively a plugin or module for that platform. At a general level seen in other cases, platforms such as operating systems, database systems and software development run-time platforms were present but more so as a dependency and part of an architectural choice for the innovation.	C1.Database Management Systems C1.Software Development Environment C2.Organisation 2a's ERP platform C2.Application server infrastructure C3.Database management systems C3.Application server infrastructure C4.Inventory integration middleware C4.Database management systems C4.Application server infrastructure C5.GIS systems C5.Database management systems C5.Application server infrastructure C7.Content management system C7.Virtual kiosks C7.Social media C8.ERPs C8.Operating systems C8.Databases C9.Enterprise social media platform

	C9.Java and J2EE
<u>Process</u> Information technology development activities, tasks, routines, methods and techniques used in innovation activity. Examples include but are not limited to software development methodologies, architectural designs, requirements management techniques, test plans, project management frameworks and change management tactics. Software development processes where part of innovation activity in most cases but cited as most influential in Cases 3, 6 and 9. In Case 8 the innovator described the development of XML based routing functionally more as adopting a process of adapting to application to application or business to business data transfer standards. In Case 3, 6 and 9 software methods were formally utilised and improved as part of innovation activity. It was very apparent and influential in the evolution of the innovation in Case 9 and described in detail in the within cases analyses in section 4.10.2.1.	C3.Software development framework C6.Software development framework C8.XML C9.Development toolset
<u>Service</u> Using resources to support innovation activity without ownership of the resources. Examples include but are not limited to contracting developers to write software, gaining access to data networks and hiring or leasing equipment. In Case 1 the initial constraints associated with wide area data network services influenced the approach to innovation. At a later stage when the constraints were eased and the service quality and availability improved this facilitated decisions to add new developments and improvements to the existing innovation. In Case 2 design was influenced by the poor availability of mobile broadband services and the software was designed to sync via an occasionally connected data transfer model. In Case 4 the availability of online booking services was a major driver and influence in requiring the innovation in itself. In Case 7 the poor availability of network impacted the operation of the system. Architectural and operational workarounds were required and part of innovation activity to facilitate content distribution.	C1.Wide Area Network C2.Mobile communications networks C4.Web site C4.Online booking services C7.Networks

5.4 Research theme – innovation outcomes

5.4.1 Introduction

Successful innovations ultimately lead to outcomes or consequences in the form of economic, social and technological change. The following section examines data relating to innovation outcomes across all cases. It also looks at factors that influence the success or failure of innovation, the impact of innovation in terms of organisational performance, the degree of novelty and the scope of diffusion associated with innovation outcomes.

Results from within-case analysis in Chapter 4 pertaining to emerging themes, social structures and information technology artefacts were filtered for relevance to innovation outcomes and then re-examined for relationships across cases.

- Section 5.4.2 examines the emerging themes using a case ordered meta-matrix. A clustered thematic map is then presented to provide an overview of the themes present across cases. The consolidated themes are then described in the context of the relevant cases.
- Section 5.4.3 examines the social structures present across cases. Within case data was consolidated by grouping social structures into roles and actor archetypes and displaying the results in the context of relevant cases.
- Section 5.4.4 examines the information technology artefacts present across cases. With-in case data was consolidated and grouped into classes of information technology and displaying the results in the context of relevant cases.

5.4.2 Themes

Within case themes were identified in chapter 4 through a process of inductive coding. Themes, associated codes, field notes and analytic memos where reviewed for any connection or relationship to innovation outcomes. The relevant themes were then identified in conjunction with the cases and a summary of memos relating to the innovation outcomes. A case ordered display is presented in table 5-14 that summarise the relevant themes and context.

Table 5-14. Case ordered display for themes relating to the innovation outcomes.

Case	Case Memos	Themes
1	Software was developed on a continuous improvement basis, adding functionality and fixing issues over a long time period. Prototyping methods were employed to allow the users to test new functions and concepts and further refine software requirements. Access to IT development knowledge and the ability to apply that knowledge was an important component of the innovation's success. Organisation 1 sourced information technology knowledge in-house. Although it did turn to external sourcing when adding new functionality around staff time and	<u>Incremental-development</u> Continuous improvement Long term evolution Prototyping IT know-how <u>Understanding-requirements</u> Collaboration with managers and users. Requirements from testing

Case	Case Memos	Themes
	attendance/rostering. However there were issues understanding requirements when external development resources were used and new controls were needed to manage this aspect of the development. Emphasis was placed on collaboration with managers and users to establish system requirements. The users and managers drove most of the functional design, but there were a range of functions introduced from the IT team. The development team demonstrated a high degree of sympathy and respect for the information technology skills and capabilities of the end-users and this may have facilitated successful deployment. Requirements appear to have been better resolved at testing as opposed to requirements gathering sessions. The platforms that underpinned the original development were replaced in the market by new innovations. These changes had a significant influence on how development proceeded and subsequently evolved moving forward. Organisation 1 had developing and maintaining skills and retaining internal staff.	Respected end-user IT capabilities Agency issues <u>IT platform-changes</u> IT market innovation IT dependencies <u>Difficulty maintaining IT skills</u> Challenge IT staff retention
2	Innovation in Case 2 involved a high degree of collaboration with a third party software development organisation. The relationship was highly interactive and based on trust. The collaborative relationship was a critical factor in the success of this innovation but it did not appear to be as effective from a software engineering efficiency perspective. However the developer cited the process as being very effective for delivering creative and innovative solutions. The incorporation and application of business knowledge, particularly of the business processes required to design an acceptable system was present in innovation activity. Ideas were tested within the system to determine the impact and effectiveness for specific requirements. There was also a need to integrate with commercially off the shelf software and equipment and the existing ERP system. Development activity phased and incremental. Each phase appeared to been set high level goals or objectives from which a series of incremental plan, design, code and test sequences were performed in close collaboration with stakeholders.	<u>Supplier-collaboration</u> Requirements gathering Trust <u>Incremental-development approach</u> Knowledge of IT development Business knowledge Experimentation Use of IT capital goods Phased development Seller-customer relationship Customer-technology relationship
3	Development activity was concerned with solving problems associated with the collection, storage, processing and distribution of information. An external third party undertook information technology development. A deliberate formal requirements process was used to elicit requirements from stakeholders and filter them to the developer. The requirements gathering process involved	<u>Interactive-development</u> Solving information handling problems Outsourced development Requirements process Long development cycle Continuous-development

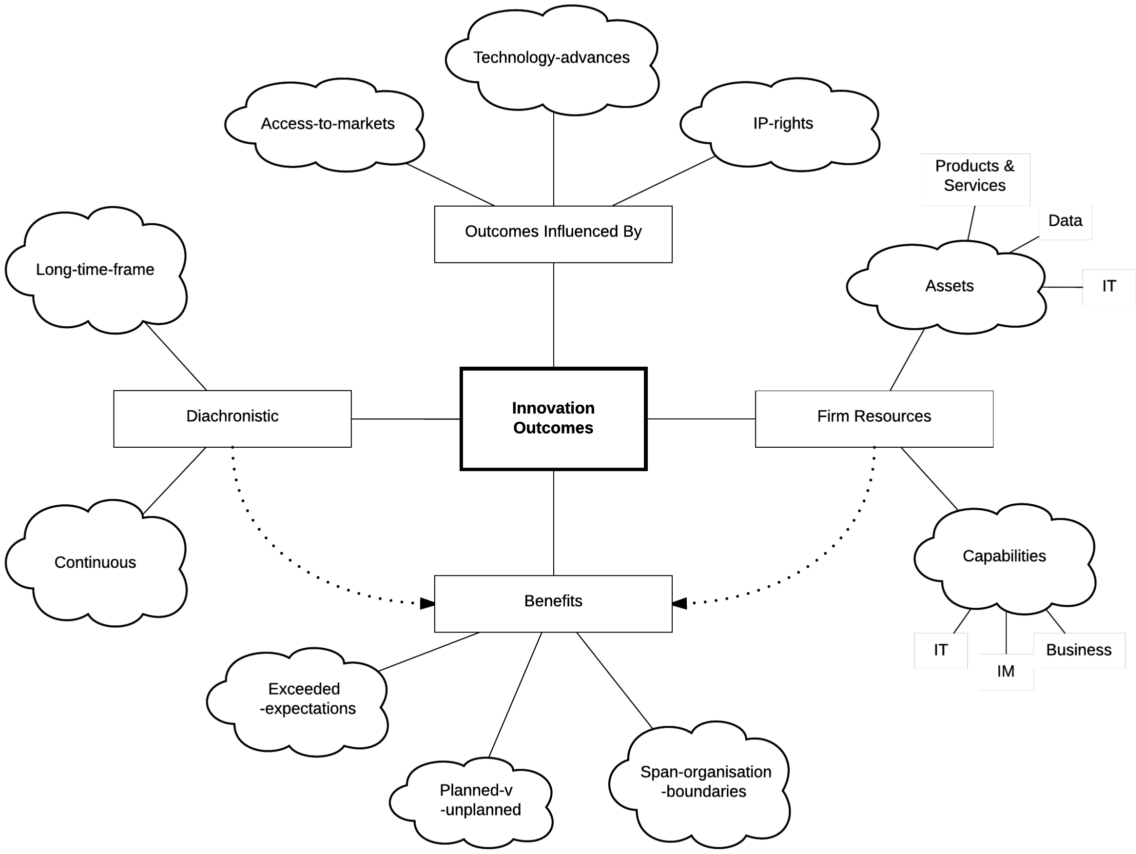
Case	Case Memos	Themes
	interaction between management, operational (farm) stakeholders and the developer and that was facilitated by an internal business analyst. Development outputs took a long time to complete.	
4	An iterative process was employed to refine the design and output of innovation activities. Specific mechanisms were employed to address uncertainties in the development process and outcomes. The outputs of incremental innovation activity produced outputs that could be tested in business operations (by the internal customer). Collaboration between internal customers and external suppliers with respect to the business requirements or fitness for purpose (quality). Internal customers and suppliers were involved in the testing process. Operational and technical knowledge was sourced internal customers and external suppliers to progress the innovation. Existing information technology assets and capabilities were used to progress innovation. New information technology assets and capabilities were introduced to progress innovation. Specific information technology assets were being used for multiple purposes or application. The middleware integration technology provided a capability to automate and simplify inventory management across a range of systems and related businesses and thus became a source of continuous innovation.	Incremental-evolutionary- approach Continuous improvement Managing uncertainty Testable outputs Collaboration-users-suppliers Requirements collaboration Testing collaboration Sources of technical knowledge Merging-using-IT-capabilities. Leveraging existing IT capabilities Introduction of new IT capabilities Role of IT platforms
5	Development progressed with increasing scale. Technology was taken from use in another sector of the economy and repurposed or adapted for use in another. There was collaboration with suppliers, competitors, academic and research institutions. Development spaned a long period of time. The incorporation and application of information technology techniques and methods to engineer the system. Access, incorporation and integration of commercially off the shelf software, operating platforms and equipment. New routines were developed for information handling. A production model or chain emerged for processing data. Large amounts of data were processed. Data assets were utilised for multiple applications and purposes.	Experimental-development Scaled approach Re-domaining Collaboration Long cycle-time Capability-building IT knowledge Technology acquisition Information management Data Data production model Volume Multiple applications
6	An essential component of the innovation throughout its lifecycle was the domain knowledge the founder of Organisation 6 had gained through his experience as a clinical pharmacist working in the public health sector. Development activity was concerned with solving a	Experimental-development Domain Knowledge Solve-a-problem End-user development platform

Case	Case Memos	Themes
	problem (associated with the collection, storage, processing and distribution of information). An end-user software development tool was used to progress development. A commercial opportunity was identified. External professional information technology development knowledge was sourced/utilised. An external and commercial IT development platform or framework was utilised. External business administration skills were sourced/utilised. A number of barriers were encountered during the commercialisation process – arguments about intellectual property rights with the founder's previous employer; mistakes in the original software design and difficulty marketing software to the health sector.	Mistakes <u>Commercial-collaboration</u> Exploit-an-Opportunity Commercial IT know-how Commercial IT platform Business know-how Barriers Product evolution
7	The creative leadership of the founding researchers drove innovation in Case 7. The same leadership prevailed though innovation activity recognising problems that needed to be solved throughout the innovation lifecycle. Leadership in Case 5 also had significant experience dealing with indigenous health issues, health promotion and education. This experience was successfully applied to the digital sphere taking key learning's from the participatory model that had been developed using forum theatre in similar contexts. Development in Case 5 was distinctly research driven and experimental in design. The development initially was split into two distinct phases, then later three with varying levels of design to meet high-level program objectives. Development was centred upon three different types of activity. In the initial phase development focused on the development of IT infrastructure and the creation of digital content. IT infrastructure development was initially concerned with the acquisition of hardware and software to operate the kiosk but in later stages this extended to having a third party design and develop a customised hardware and software platform to manage and deploy interactive multimedia content. Formal evaluation processes were undertaken to examine the project outcomes and this information informed the requirements for the next phase. There was a high degree of interaction and collaboration undertaken between users or community stakeholders (customers) and the development teams in relation to the digital content. There was also a high degree of supplier collaboration in the development of IT infrastructure. Organisation 7 had sourced the expertise for kiosk and content management system development from external parties throughout the development lifecycle.	<u>Leadership</u> Entrepreneurial Domain experience <u>Experimental-development</u> Phased approach Content development IT infrastructure development IT capability development Evaluation <u>Collaboration</u> Customer collaboration Supplier collaboration
8	The development was driven by requirements that were	<u>Testing</u>

Case	Case Memos	Themes
	created dynamically from testing. Specialised knowledge of software design and development were used to improve or resolve issues from tests. Software testing focused on resolving software defects and alignment its fitness for purpose with the use cases. Testing was undertaken by users/customers of the software. Testing was a collaborative venture with customers. A formal organisation arrangement was made between the developer and systems integrator. Ecosystems of users and systems integrators focused on particular software solutions were used to market and diffuse the product. Development and diffusion occurred over a long time frame.	Dynamic development Software engineering knowledge Quality and reliability issues Customer testing Collaboration Customer testing Joint venture Market-diffusion Software ecosystems
9	The software developed as part of the innovation in Case 9 was adaptive and incremental and whilst it was initially informal it followed the general principles of an agile development process. Innovation activity in Case 5 was characterised by informal planning, customer collaboration and short development/release time frames. Two important knowledge based processes also appeared to be present within the innovation activity (1) the application of game mechanics to software functionality; and (2) the evolution and improvement of software engineering and development capabilities Challenges were associated with resourcing and running development activity. Particular challenges in relation to the organisation of its resources so they were focused on development and not distracted by operational support problems and the adoption new development techniques to assist with the speed and efficiency required to meet the demands of it customers (and potential customers). Interaction with customers to test and provide feedback on the software features and reliability. Access to a network of platform users and would be customers. Access to third party solution integrators and resellers (partner networks) associated with the same platform.	Agile-development Gamification Software development capabilities Customer collaboration Operational challenges Development challenges Short time-frames Platform-ecosystem Customer access Partner network

Themes identified in table 5-14 where further analysed and consolidated across cases. Ten themes emerged that were clustered into four high level organising themes that were interpreted as relating to innovation outcomes. A thematic map provides an overview consolidated and clustered themes in figure 5-3.

Figure 5-3. Thematic map for consolidated and clustered themes for innovation outcomes.



5.4.2.1 *Firm resources*

In the context of this research the firm resources are defined to encompass assets and capabilities controlled by an organisation that enable the organisation to improve its efficiency and effectiveness (Barney 1991). Assets are taken as tangible and intangible inputs that can be used in the organisations production process, whereas capabilities are defined as the ability to deploy those assets into productive use (Amit & Schoemaker 1993).

The development and improvement of firm resources was a common theme associated with innovation outcomes across all cases. Firm assets such as products and services, data, and information technology were continuously created and improved during innovation. Similarly, firm capabilities, particularly information technology development and information management capabilities were created or improved as part of innovation activity.

Table 5-15. Firm resources consolidated themes.

Consolidated Theme	**Within case instances**
<u>Assets</u> Production inputs in the form of IT capital goods, including software and data were routinely created or improved as part of innovation activity. In some instances these assets were created and placed into operations as part of the innovation. In other instances the creation and improvement of assets enable the next phase of innovation to proceed. In Case 1 software development platforms and infrastructure were used to develop a software asset. In Case 2 several IT assets were assembled and software developed to enable the innovation. In Case 4 middleware was acquired and placed into production as part of the innovation. In Case 5 data assets were created that allowed new methods of production. In Case 6 a commercial IT development platform was acquired and used to develop software. The primary outcome of innovation in Case 6 was also a software asset. In Case 7 assets were combined to distribute multimedia content. Case 7 also developed the complementary content (data) assets that enable the innovation. Cases 8 and 9 do explicit describe their innovation outcomes as assets but in both instances software products (assets) were the outcome of their innovation.	C1.IT-staff-retention C2.IT-capital-goods C4.IT-capital-goods-services C5.technology-aquisition C5.volume C7.content-development C3.data-advanatage C6.commercial-it-platform C7.IT-infrastructure-development
<u>Capabilities</u> Information technology development, information management and business management capabilities were developed and/or used across cases. These capabilities were in effect abilities that could be used to deploy the various assets created or available as part of the innovation. Cases 1,2,4,5,6,7 and 9 used and/or developed IT capabilities. Case 5 improved and developed new information management capabilities. Cases 6, 8 and 9 developed new and/or improved business management capabilities. Case 9 developed a new capability to use gamification theory in software development.	C1.IT-know-how C2.Business-knowledge C2.IT-development-knowledge C4.data-design C4.existing-capabilities C4.it-management-processes C4.marketing-strategy C4.role-of-platform C5.capability-building C5.data-production-model C5.information-management C5.IT-knowlege C6.business-admin-knowhow C6.commercial-it-knowhow C6.domain-knowledge C7.it-capability-development C9.business-capabilities C9.gamification C9.software-development-capability

5.4.2.2 Diachronistic

Innovation outcomes produced in most cases were the product continuous development through relatively long timeframes. The terminology "diachronistic" has been used to represent this cluster of themes to highlight the role of time.

Table 5-16. Diachronistic consolidated themes.

Consolidated Theme	**Within case instances**
<u>Long-time-frame</u> Long innovation time frames were influential in innovation decision making and innovation activity, it is also influential for innovation outcomes. Because innovation activity in the majority of case studies is characterised by relative long time frames, innovation multiple outcomes are identified within single cases with varying impact. These outcomes do not always translate into success with several cases experiencing adverse or unsuccessful outcomes in some instances. For example in Case 3 there was difficulties with user acceptance. In Case 6 the initial software design was dumped as it was seen a taking the wrong approach. Recounting analysis from innovation activity: • Cases 1,3,5,6,7 and 8 innovation activity spanned more than 10 years. • Cases 2 and 4 it was more than three years. • In Case 9 the innovation was in its infancy and the innovation owner was forecasting an extended lifecycle for the innovation as well.	C1.long-term-evolution C3.long-development-cycle C5.long-cycle-time C6.long-time-period C8.long-time-frame C9.short-time-frame
<u>Continuous</u> The continuous nature of development is also highlighted in the analysis of innovation activity in section 5.3.2.1**Error! Reference source not found.**. Continuous development also appears to generate continuous outcomes. As previously noted in section 5.3.2.1**Error! Reference source not found.** an in-depth review of each case reveals there are no examples in any case under study of an innovation having being developed and not incrementally improved as it diffused into operations. However evidence was strongest from the themes emerging from Cases 1,4,6 and 8 In section 5.3.2.1 we examined innovation activity but there are complementary experiences for innovation outcomes. In Case 1 software improved functionality and new IT development capabilities emerged over time. In Case 4 integration automated and refined workflow through staged cycles. In Case 6 the software innovation evolved from a clinical pharmacy focus into a platform that supported medication management, medication knowledge management, electronic referrals and integration of patient diagnostic information from other health	C1.continuious-improvement C4.incremental-improvments C4.leveraging-initial-outcomes C6.product-evolution C8.dynamic-development

Consolidated Theme	Within case instances
applications. In Case 8 continuous testing and feedback from customers improved the quality and reliability of the innovation and allowed new document routing methods to be supported e.g. XML and database routing.	

5.4.2.3 *Benefits*

It is somewhat implicit that innovation is undertaken in order to generate some form of advantage or improvement for the innovator. Benefits were therefore expected to be present in innovation outcomes.

Benefits across cases were seen to be both planned and unplanned i.e. some benefits were part of planned or organised innovation objectives whilst others emerged unexpectedly or serendipitously. In some cases the benefits exceeded initial expectations delivering better than expected outcomes for the innovator. In several cases benefits spanned organisational boundaries to provide advantages or improvements for stakeholders.

Table 5-17. Benefits consolidated themes

Consolidated Theme	Within case instances
Planned-v-unplanned Benefits were expected to be found across all cases, however they took on two forms – (1) those which were planned, often forming part of the initial innovation objective or that were generated at specific stages of innovation; and (2) those that were unplanned and emerged either unexpectedly or by virtue of serendipity. All cases identified some form of planned objective that was achieved for their innovations. Case 3 provides an example where one planned benefit was not realised. In Case 5 innovation activity was carefully planned with specific benefits targeted, but the innovator discovered that the data collected by LIDAR technology was able to be applied across a range of business needs. In Case 7 outcomes from the project at the end of the three-year phase were mixed or unclear and at the community level the project had been unable to demonstrate any health literacy or behavioural changes. But the innovation was continued and eventually delivered benefits at the marginally different level forming a social business enterprise. In Case 8 the initial benefits were planned but the revenue from the large BPO vendor was not planned. It led the innovator to ponder missed opportunities. In Case 9 the benefits were serendipitous i.e. not completely	C1.innovation-objective C2.commercialise-opportunity C2.customer-tech-relationship C2.customer-tech-relationship C2.data-analyitics C2.seller-customer-relationship C3.operational-alignment C3.unplanned-functionality C3.usability-issues C4.uncertain-outcomes C5.anticipated-benefits C5.unanticipated-benefits C6.commercialsiation C7.evaluation C8.missed-opportunities C8.unexpected-outcomes C9.serendipity C9.uncertainty

Consolidated Theme	Within case instances
intentional but desirable and made possible by perceptive innovation activity.	
Exceeded-expectations Several cases realised benefits that far exceeded expectations that were anticipated during innovation decision-making. In Case 5 LIDAR data was able to used for boarder variety of application of uses than first anticipated and there was also the possibility of commercial services and expertise being offered to smaller industry operators. The adoption and modification of technologies eventually changed the operational model for forest resource management. In Case 7 the research project was effectively commercialised and emerged to form a social business enterprise. In Case 8 success exceeded the initial plans and possibilities of the innovation. In Case 9 the innovation was taken up by large corporate organisations on a global scale. Other cases experienced less significant but nonetheless greater than expected benefits from their innovation activities.	C5.commercialise-service C5.multiple-applications C7.social-business-enterprise C8.success C9.global-diffusion
Span-organisation-boundaries The benefits of innovation were also seen to span organisational boundaries. Whilst the notion of spillovers and externalities are a well researched and understood economic phenomena, the specific account in several cases was that the benefit realisation spaned the organisational boundaries to others who collaborated with the innovation. For example: In Case 2 the supplier organisation was positioned to share in the commercialisation benefits should they have materialised. In Case 3 the supplier was gifted the opportunity (IP) to commercialise the software with other organisations. In Case 5 research institutions were able to obtain grants and project funding for research because the innovator had commenced innovation activity. In Case 6 the supplier of development resources was able to become an investor/part owner of the business that emerged. In Case 7 funds associated with the innovation were expended in the communities that participated in the health education programs. In Case 8 both organisations benefited from the success of the innovation in the form of a joint venture.	C2.commercialise-opportunity C3.outsourced-development C5.collaboration C6.commercial-it-knowhow C7.customer-collaboration C8.joint-venture

5.4.2.4 Outcomes influenced by

Innovation outcomes where potentially influenced by a range of factors either during decision-making or as part of innovation activity. The within case analysis of individual innovations suggests that these factors are complex, differ from case to case, and are potentially difficult to identify. The cross case analysis focused on factors that appeared common across some cases. These factors included gaining access to markets, dealing with intellectual property rights, and addressing advances in information technology platforms that impacted the innovation or one of its dependencies.

Table 5-18. Outcomes influenced by consolidated themes.

Consolidated Theme	**Within case instances**
Access-to-markets Access to customers and software markets was an important factor influencing innovation outcomes in cases where the innovator was an ICT producer i.e. they were selling a product or service. In Case 6 the innovator cited difficulties dealing in IT with government health organisations as limiting the success of the innovation. In Case 8 and 9 the innovator utilised user and business partner networks associated with the platforms that their innovations were designed to work with to access markets for their innovations. In Case 9 the innovator was also able to access markets with large customers.	C6.dealing-with-GHOs C8.software-ecosystems C9.channel-architecture C9.large-customers
IP-rights Assuring intellectual property rights also emerged as an influential factor for innovation outcomes in three cases. In Case 6 an intellectual property dispute had to be resolved between a former employer to assure the innovation was unencumbered. In Case 7 intellectual property was secured in the form of software source code to enable the innovation to continue after a supplier went into insolvency. In Case 8 a patented had already been taken out for a very similar innovation, however the innovator had specific rights to use their intellectual property on the basis that their innovation predated the patent. The innovator in case investigated the possibility of patent protection but found it economically prohibitive.	C6.intellectual-property-rights C7.software-issues C8.intellectual-property C8.recognised-IP
Technology-advances Advances in information technology platforms and systems also influenced innovation outcomes. In some instances innovations had operating dependencies linked to various complementary information technologies platforms. When changes or advancements occurred with these technologies often changes were required with the innovation. Furthermore innovation within the information technology marketplace often made various operating systems or platforms redundant or obsolete forcing a search for new solutions. On the other hand advances or improvements in some information technologies enabled improvement or enhanced the success of innovations. In Case 1 the development platform used to compile and support the software innovation become obsolete, development knowledge and skills become difficult to source and the organisation was forced to rebuild the software using a different development platform.	C1.IT-dependencies C1.IT-market-innovation C2.infrastructure-constraints C3.technology-market-changes C5.redomaining C7.technology-advancement C8.technology-market-changes C9.developemnt-challenges

Consolidated Theme	Within case instances
In Case 2 iPad tablets and advances in user adoption of internet technologies lowered the costs and allowed boarder support for the software innovation. In Case 3 the innovation reached end of life when an industry platform gained improvements to support activities particular to the local industry and made the innovation obsolete. In Case 5 LIDAR technology advancements reduced the cost and improved the business case for innovation within the organisation. In Case 7 advancements in multimedia content development and deployment tools improved the content development options and useability for kiosks. In Case 8 operating systems changes to 64bit required software to be rewritten. In Case 9 new versions of the enterprise social media platform required advanced version control capabilities to be developed. However this change also allowed new features in the platform be exploited within the software innovation.	

5.4.3 Social structures

The previous section re-examined, and clustered and consolidated themes in the context the innovation activity across all cases. Similarly the role of social structure identified within cases was re-examined to consolidate and identify roles and actor archetypes that were present and related to innovation outcomes.

Roles and actors identified within cases in Chapter 4 were filtered in terms of their influence upon innovation outcomes and then consolidated across all cases. Similar or related roles were grouped together and classified into higher-level archetype roles and actors and displayed in table 5-19.

Sixty-seven roles and actors were interpreted as relating to innovation outcomes across all cases. These social structures were clustered into nine archetypes – customer/users, developers, government, incubators, industry networks, innovation owner, leadership, research institutions and suppliers.

Table 5-19. Consolidated list of social structures influencing innovation outcomes.

Role/actor archetype	**Within case instances**
Customer/User Individuals and organisations that utilise the outputs of the innovation, the IT artefacts, process, changes that are implemented. The term user and customer are used interchangeably with the term “customer” being more oriented towards the ICT-producing sector that tend to sell the outputs on a commercial basis. The presence of customer and users in innovation is somewhat inherent. Customers and users had a significant influence on the outcomes of innovation activity across all cases. Identified in section 5.3.3 the collaborative nature of development and the interaction between developers and customers/users for requirements gathering and testing perhaps understandably influences user acceptance and customer satisfaction, which in turn can impact on innovation success. In Case 1 the developers close attention to user and store managers needs and their capabilities with information technology drove high levels of user acceptance. When the organisation changed the level of interaction through external development outcomes were not so successful. In Case 3 poor alignment of the software with operational decision making needs challenged aspects of the software’s acceptance and use by operational staff. In Case 7 direct involvement of the user communities to create content facilitated success with other communities because the context was familiar and linked to cultural understandings of the target users.	C1.Store managers C1.Users C2.Organisation 2a sales staff C2.Organisation 2a’s customers C3.Operational staff C4.Marketing department C4.Internal business customers (users) C5.Resource management specialists C5.Operational staff C6.Hospital clinical pharmacy practices C6.Clinical pharmacists C7.Remote indigenous populations C8.Organisation 8b customers C8.BPO organisation C9.Users
Developers Individuals and organisations that were involved in the business and technical changes. Includes software developers that designed and wrote code, information technology specialists that assembled or configured information technology artefacts, change managers who deployed and implemented change. Understandably developers having played an extensive role in innovation activity also were seen to be influencing the overall outcomes of innovation. In most cases knowledge of IT development and linking this knowledge with domain knowledge about the area of application was the most common influence seen across cases.	C1.In-house IT developers C2.Organisation 2a IT specialist C3.Business analyst/project manager C4.Internal IT specialists C5.Internal IT specialists C5.Internal spatial information specialists C5.Biometric modelling specialists C7.Organisation 7 technical manager C8.The software developer C9.Software developers
Government State or federal government organisations. In Case 6 the public/government owned and operated health sector was influential in the innovation decision process.	C6.Public health sector
Incubator An organisation providing facilities and resources for the innovator to develop and commercialise the design. Resources include equipment, workspace and support staff with skills in business, finance and/or marketing. As for innovation activity (see section 5.3.3) incubator organisations provided assistance and support for transitioning the organisations and	C6.Incubator business C7.Incubator

Role/actor archetype	Within case instances
innovations in Cases 6 and 7 into success commercial positions.	
<u>Industry Network</u> Business networks of like-minded organisations formed around a specific IT platform or common business objective. Across cases this included other social structures such as suppliers, competitors and customers. In Case 5 like-minded industry organisations shared knowledge about LIDAR technology implementation. This allowed the knowledge base of LIDAR technology and its application and implementation into the forestry industry to be expanded and ultimately lead to successful diffusion. In Case 7 healthcare organisations were partial funders of the research and development activities. However the low prioritisation of health education by health practitioners in the target communities was considered to have adversely impacted the outcomes of innovation. In Case 8 the ERP partner networks and the associated marketplaces for add-on modules to support the platforms was linked to successful diffusion. Similarly in Case 9 a large business partner network was linked to gaining customer access and the establishment of a distribution network for the innovation. Case 9 also obtained important knowledge from gamification experts that were important for the innovation's development and success.	C5."Like minded" industry organisations C7.Healthcare organisations C7.Health practitioners C8.ERP Partner network C9.Gamification experts C9.Platform Partner network C9.Software distributors
<u>Innovation Owner</u> An individual and/or organisation that controlled and/or appropriated the commercial benefits of the innovation. The presence of an innovation owner is an inherent social structure involved in innovation activity and hence present across all cases.	C1.Organisation 1 C2.Organisation 2a C3.Organisation 3 C4.Organisation 4 C5.Organisation 5 C6.Organisation 6 C7.Organisation 7 C8.Organisation 8a C8.Organisation 8b C8.Joint venture company C9.Organisation 9
<u>Leadership</u> Leadership is used in the social structure context of the cases to refer to an individual or group within an organisation responsible and actively providing guidance or direction to others in relation the business or the innovation objectives. Leadership involvement was influential in the progress and outcomes of innovation in Cases 1, 2, 3, 6, 7 and 8. In Case 7 leadership persisted with the prospects on success despite research evaluation showing the program had had little impact upon health education outcomes. This persistence lead to successful outcomes for the innovation where in other circumstances the program may have been abandoned. In Case 8 the business owner of a systems integration business pushed the software developer to improve the quality and reliability of his software, where otherwise success may have been limited.	C1.Organisation management C2.Organisation 2a business owners C3.Senior management team C6.Business owner/founder C7.Organisation 7 founders C8.Business owner Organisation 8b

Role/actor archetype	Within case instances
Research Institution Organisations where the primary business activity is research. Research institutions participated or influenced research and development and in one cases provided administrative and financial support. In Case 5 academic and research institutions collaborated with industry partners to facilitate advanced research and development which assisted in achieving successful diffusion of the innovation into the forestry industry In Case 6 academic research institutions also had a role in IP based disputes around the failed element of the software. This was a challenge for the innovator to overcome. In Case 7 academic institutions both hindered and advanced the success of innovation. The administrative structures associated with the academic institution was seen as non-conducive for innovation, however, at a later stage an academic institution provided access to the incubator organisation and facilities.	C5.Academic and research institutions C6.Academic research institution C7.Research program C7.Academic institutions
Supplier An individual or organisation that provided goods and/or services as inputs into innovation activity. In some instances the supplier was also a developer in providing software design and development services. Suppliers also appeared in several industry network structures. Many suppliers played significant roles in software development and the supply of capital goods and services that were essential to innovation success. In Case 2 the innovator commenced a phase of outsourced development, during this phase the organisation found that there were agency issues between users and developers around requirements and testing that had the potential to adversely impact progress of the innovation. From all accounts the organisation was happy with the developers capabilities but found problems with formal requirements and testing processes. In Case 7 the supply arrangements became problematic and threatened the ongoing progress of innovation. The supplier providing the kiosks and content management software went into insolvency leaving unfinished kiosks and concerns about access to the content management source code. Whilst these issues were resolved in Case 5 the case demonstrates how outcomes can also be hindered by supplier arrangements.	C1.External software developers C2.Organisation 2b C2.Organisation 2b software developers C3.External software engineer C4.External software vendor (suppliers) C5.External LIDAR data collection services C6.Software development business C7.Multimedia developers C7.Kiosk/IT Partners C9.Platform vendor

5.4.4 Information technology artefacts

The previous section re-examined social structures in the context of innovation activity across all cases. Similarly the role of information technology artefacts identified within cases was re-examined to consolidate and identify classes of information technology that were present and influential for innovation outcomes.

Information technology artefacts identified within cases in Chapter 4 were filtered in terms of their relationship to innovation outcomes and then consolidated across all cases. Similar or related information technologies where grouped into classes of information technology and presented in table 5-20.

Sixty-two information technology artefacts were interpreted relating to innovation outcomes across all cases. These artefacts were clustered into nine relatively generic classes of information technology artefact – applications, architecture, data, hardware, intellectual property, platforms, processes and services.

Table 5-20. Consolidated list of information technology artefacts influencing innovation outcomes.

IT Artefact archetype	**Within case instances**
<u>Application</u> Information technology products or services that focus on a specific function or solve specific business problems example would be a software products. In many cases applications were either the major output of innovation or a dependency (input) from innovation. In Cases 1,2,3,6,8 and 9 software applications were the primary innovation output. In Cases 1,3,4,7 and 8 software applications were major dependencies or a complementary resource for innovation.	C1.Retail software C1.Communication utility C1.POS Equipment C2.Mobile sales ordering software C3.Aquaculture production control software C3.Microsoft Excel C4.Existing property management systems C6.Medication management software C6.Prototype software C7.Mobile applications C8.Virtual printer software C8.Email C8.Fax C9.Rewards and recognition software module.
<u>Architecture</u> The combination, arrangement and assembly of related artefacts to allow the innovation or a component of the innovation to function. The configuration and assembly of complementary IT artefacts was influential in many cases. In Cases 1,2 and 3 the assembly of software libraries, database platforms and related hardware and operating systems impacted the ability for the software innovations to operate. In Case 4 the innovator data models supported the innovation and made the process of integration more efficient and effective. In Case 5 the innovation was dependent on the overall architecture and incorporation of the data handling processes. In Case 7 the innovation was dependent on the overall architecture of kiosk hardware, content management software and digital multimedia	C1.System architecture C2.System architecture C3.System architecture C4.Data models C4.System architecture C5.Data models C5.System architecture C7.System architecture

IT Artefact archetype	Within case instances
content.	
Data In the context of this study we take data as being pieces of information that have been collected, stored and processed in a digital form. Examples include numerical data, text and multimedia content. In Case 2 sales staff and customer order entry behavioural data was utilised to enhance the outcomes from innovation. In Case 3 farm production data collected as part of the innovation was used to provide a competitive advantage when the industry was facing production problems. In Case 5 LIDAR data was able to be leveraged across many facets of the business. In Case 7 digital multimedia content was used to promote health outcomes. The libraries created were also reused and enhanced with as new multimedia platform capabilities became available.	C2.Sales data C3.Farm production data C5.LIDAR Data C7.Digital multimedia content
Hardware Physical information technology equipment and computing resources either acquired, built of assembled. Hardware artefacts provide an interface between virtual or logical artefacts and the physical world. Hardware artefacts are inherent in information technology innovation however their influence varies and in some cases hardware is not mentioned. In Case 2 the use of tablet computers was novel at the time and an essential characteristic of the innovation's success. In Case 5 LIDAR equipment was an essential component of the innovation. In Case 7 multimedia kiosks were used through most phases as the primary method of deployment for content in remote communities.	C2.Tablet computers C5.LIDAR technology C7.Kiosks
Intellectual Property Copyrights, patents and trademarks that create artefacts for the protection of invention and design. In Case 6 an intellectual property dispute was a major hurdle to overcome for the innovation to progress and achieve outcomes. In Case 8 the status of the intellectual property generated through the early stages of innovation was influential in the two organisations forming a joint venture to allow it to engage and innovate with larger scale clients.	C6.Intellectual property C8.Intellectual property
Platform Systems from which other systems and technologies can be developed. They differ from application artefacts by virtue of their variety and scope for use and their support for creating new applications. The role and influence of software platforms in innovation activity was outlined in Section 5.3.4. Because the role of platforms was substantial and there were often dependencies or complementary relationships with other IT artefacts, IT platforms were also influential across many cases. For example in Case 9 the enterprise social media platform was the basis for innovation the software innovation was completely	C1.Database Management Systems C1.Software Development Environment C2.Organisation 2a's ERP platform C2.Application server infrastructure C3.Database management systems C3.Application server infrastructure C4.Inventory integration middleware C4.Database management systems C4.Application server infrastructure

IT Artefact archetype	Within case instances
dependent on that platform.	C5.GIS systems C5.Database management systems C5.Application server infrastructure C7.Content management system C7.Virtual kiosks C7.Computing Infrastructure C7.Social media C8.ERPs C8.Operating systems C8.Databases C9.Enterprise social media platform C9.Java and J2EE
<u>Process</u> Information technology development activities, tasks, routines, methods and techniques used in innovation activity. Examples include but are not limited to software development methodologies, architectural designs, requirements management techniques, test plans, project management frameworks and change management tactics. Software development processes were influential for innovation outcomes in Cases 6 and 9. In Case 6 the use of a proprietary development framework enabled the innovator to quickly develop an early proof of concept and ultimately to obtain commercialisation funding and access to the incubator. In Case 9 software methods were influential in the evolution of the innovation in Case 9 and described in detail in the within cases analyses in section 4.10.2.1.	C6.Software development framework C9.Development toolset
<u>Service</u> Using resources to support innovation activity without ownership of the resources. Examples include but are not limited to contracting developers to write software, gaining access to data networks and hiring or leasing equipment. In Case 1 the initial constraints associated with wide area data network services influenced the approach to innovation. Once these constrains were alleviated the organisations was able to achieve improved outcomes and add new features to the innovation. In Case 2 poor availability of mobile broadband services and the software impacted In Case 4 the availability of online booking services was a major component of the innovation influencing not only the way the approached the innovation but also the outcomes associated with integration. In Case 7 the poor availability of network impacted the operation of the system and created unexpected overheads for managing content distribution impacting innovation outcomes.	C1.Wide Area Network C4.Online booking services C7.Networks

5.5 Reflections

In Chapter 4 an analysis was conducted on data relating to nine case studies of innovation that involved the use and/or development information technology. The independent analysis from Chapter 4 included within case interpretation of the activities and events (themes), social structures and information technology artefacts experienced by participants involved with the innovation.

Results from the within case analysis of activities and events (themes), social structures and information technology artefacts was partitioned into three high level research themes developed in Chapter 2 concerning the decision to innovate, innovation activity and innovation outcomes. Data was then consolidated and clustered into related activities and events (themes), social structures, and information technology artefacts, to provide an interpretation of innovation across all cases.

The cross case analysis highlights a range of entities, mechanisms and structures interpreted as being present across cases in the context of high level research themes.

In Chapter 6 these findings are further interpreted and discussed in the context of the research objectives and questions.

6 INTERPRETATION AND DISCUSSION OF FINDINGS

6.1 Introduction

This chapter provides an interpretation and discussion of the data analyses conducted in Chapter 4 and Chapter 5. It provides interpretation of the innovation practices within and across nine cases studies involving the development or use of information technology and discusses the findings in relation to existing research literature. More specifically this chapter presents the following three contributions.

First, this chapter generates important insights into IT innovation and presents a dynamic model of IT innovation based on organisational approaches and experiences in IT innovation identified in the key findings of this research. This model is an evolution/reinvigoration of the A-B-C heuristic model grounded in evidence analysed in this thesis.

Second, this chapter also discusses the findings in the context of the research literature to examine similarities, differences and gaps within current theory. Based on the interpretation and discussion, this thesis presents a knowledge framework designed to extend exiting understanding of organisational approaches and experiences in IT innovation and support future case study research to reveal mechanisms and processes that contribute to dynamically determining what IT innovation is, how IT innovation is achieved, and how IT innovation can be analysed effectively.

Third, this chapter presents a synthesis of the key findings in relation to the research problem and questions associated with this research.

The chapter is structured in the following sections:

- Section 6.2 revisits the analysis from chapters 4 and 5 and presents the preliminary findings of the cross case analysis reflective interpretation and discussion.
- Section 6.3 presents an empirically grounded model of IT innovation for the nine case studies guided by the interpretation and discussion in section 6.2.

- Section 6.4 discusses the findings embodied in the dynamic model of IT innovation looking at contradictions, similarities and gaps in the context of existing literature relevant to IT innovation theory and practice.
- Section 6.5 generates knowledge framework from the discussion in section 6.4, integrating insights from information systems research and contemporary innovation theory grounded in the multi-case analysis and findings. The framework is aimed at extending existing notions of IT innovation and moves beyond the limitations of diffusion and adoption perspectives previously employed in the IT innovation/implementation literature. The framework also highlights the continuous and sustaining nature of IT innovation.
- Section 6.6 provides a synthesis of the findings for this research. It utilises the preliminary findings from the dynamic model of IT innovation presented in section 6.3 and the knowledge framework presented in Section 6.5 to address the research questions and objectives for this study.
- Section 6.7 concludes the chapter with a summary and reflection of the emerging concepts.

6.2 Findings from the cross-case analysis

This section provides a discussion of the preliminary findings from the cross case analysis, reflecting and consolidating the themes to provide a starting point for further interpretation and analysis in the context of the research questions.

6.2.1 The decision to innovate

The reasons, motivations and objectives driving innovation across the nine case studies varied by context. Most innovation decisions could be seen to be concerned with solving a problem, exploiting an opportunity or dealing with decisions that had to be made at different stages or phases of innovation.

Innovation decisions were also influenced by innovation owners and driven by leadership. Customers, users and developers also appeared have varying degrees of input into innovation decisions. Problems, functional gaps or opportunities associated with software applications and information technology platforms were also influential in innovation decisions.

6.2.1.1 Solving problems

Information systems and technologies embody the knowledge of productive information handling processes (Baetjer 1997). In most cases innovators were looking to solve problems associated with the collection, processing, storage and distribution of information. This objective was pervasive across the majority of cases, but complicated by information technology solution search problems and changes with complementary information technologies for which their innovations were dependent.

For many innovators problems emerged in searching for solutions to specific organisational or business problems. Despite information technology solutions having already been in place or available within commercial markets, many innovators pursued new developments on the basis that the available solutions were not suitable or fit for their intended purpose (imperfect).

Innovators also faced the issue of complementary dependencies associated with information technology solutions. Application software was often dependent on information technology operating platforms and again these artefacts were also dependent on information technology infrastructure, services, processes, and ultimately the way they were configured to work together (architecture).

Problems were also required to be solved on a continuous basis, as uncertainty and incremental methods deigned to deal with those uncertainties introduced or revealed new problems as innovation progressed.

6.2.1.2 Exploiting opportunities

For some cases the main driver for the decision to innovate was the opportunity to exploit the favourable or advantageous conditions created by developing new or improved information technology solutions. This theme was present in all innovations emerging from organisations that operated in the IT producing sector, where the objective was to appropriate the benefits of innovation by offering the innovation for sale to other organisations. Decisions driven by entrepreneurial leadership and vision were influential in this type of decision-making. Similarly was the opportunity to commercialise or profit directly from the development of information technology products and services.

Not pervasive but influential in the context of innovation was the concept of taking technology from one domain of application, and modifying or customising it to work in another. In the cases where this was accomplished innovation appeared to be highly successful.

6.2.1.3 Decisions in phases

Incremental development approaches were used in all cases. Incremental methods are concerned with processes and activities. The implication for decision making is that at the end of each increment or phase, new problems or opportunities were revealed that required varying levels of decision that were often linked to reasons, motivations, and/or objectives driving innovation.

Innovations across all but one case were characterised continuous activity spanning several years. It would appear that once the innovation was initially introduced innovation owners, customers and users would seek to implement improvements on an ongoing basis, possibly until the innovation was no longer in operation. This again meant that innovation decisions were continuously been made to solve problems, exploit opportunities and deal with dependency changes.

One reason for the decisions being made in incremental phases appeared to be the apparent uncertainty of outcomes associated with IT innovation. In effect decision stakeholders were facing the prospect of making decisions with limited or incomplete information. In some instances the scope of activity was deliberately constrained in order to achieve predicable outcomes and limit risks. Additionally, the outcomes of some phases where used to justify the next. In other cases entrepreneurial approaches were taken about decisions through various stages of development.

6.2.2 Innovation activity

Innovation activity was diverse across all cases. Data analysis explored development activity that was interpreted as being related to the implementation of innovations. It included activities such as: research and experimental development, the acquisition of capital goods and services, the acquisition of external knowledge, and innovation deployment.

Innovation activity was characterised by: incremental approaches to the development of information technology innovations; collaboration, predominately involving customers, users, developers and suppliers; the acquisition of information technology capital goods and services; and the transfer of domain knowledge associated with information technology development, the area of application, and to a lesser extent business marketing and administration knowledge.

Innovation activity involved a diverse range of social structures. Most prevalent were activities undertaken by or with customers and users, developers, innovation owners and suppliers. Activity directed by senior leadership or involving industry networks was influential in cases where it was present. Less prevalent were activities involving government, research institutions, and incubators.

Information technology artefacts were intricately involved in innovation activity, either as input to be utilised for innovation activity or as output of innovation activity. For the IT producing organisations information technology artefacts were not unexpectedly the primary outputs of innovation. The majority of innovation activity appeared to involve software applications and their operating platforms. Information technology architecture appears influential in cases where it is present. Several cases make specific mention of data as an important artefact for innovation activity. The direct influence of hardware artefacts is not as profound as its software counterparts, but implicit in terms of it presences for almost all IT innovations. Similarly process and services artefacts are discussed in some cases, but they are not always mentioned despite being clearly be required to accomplish some IT innovations. The notion of intellectual proprietary as an information technology artefact involved in innovation activity arose in two cases and was particularly influential issue for those cases.

6.2.2.1 Incremental development methods

Incremental development methods dominated innovation activity in all cases. Some cases were decidedly phased and experimental like, where the scope of activity was constrained to allow information to be gathered about the suitability and feasibility of innovation activity. In other cases the incremental approach was focused on building prototypes for useable outputs and then continuously improving the reliability and functionality in collaboration with the users or customers.

The role of uncertainty was seen to be influencing the incremental approaches. Innovators cited issues understanding exactly what customers and users required (or desired). Thus requirements information was often incomplete or unavailable, and the outcomes of innovation ultimately uncertain. Such issues were emphasised in section 6.2.1.3 relating to innovation decisions and it would appear that the innovators response was to manage this risk by developing innovations to a point where customer or user feedback could be obtained.

Incremental requirements management and user acceptance testing were prevalent in many cases. Linked to the uncertainties of user requirements and the quest for feedback. Much of the collaboration described as part of innovation activity was related to these processes.

Innovation activity in the cases also spanned relatively long time frames. In most cases development was continuous through the operational life of an innovation. One important characteristic of information technology is that it is easily improved at relatively low cost, often without the need for major equipment (hardware) changes. This characteristic appeared to be exploited by all innovators across the nine cases studies. As a result, innovation spanned long periods of time. For several cases where the experimental approach was taken, this too may have contributed to the long time frames, as in some cases each phase was subject to evaluation and then justification of the next.

6.2.2.2 Collaboration

Collaboration between developers and customers/users were highly prevalent in innovation activity. Activity was predominately focused on the requirements gathering and management process, converting customer/user requirements into specifications or informal understandings of what to build, assemble or code. Similarly acceptance-testing activity (formal or otherwise) provided feedback on activity outputs to allow better alignment between the innovation objectives and the needs of customers/users.

Where external suppliers completed software engineering activities a similar level of collaboration occurred between users and developers. In several instances, a specialist was employed on behalf of the innovator to facilitate requirements and testing processes.

In several instances industry networks were utilised to progress innovation diffusion. In two instances industry networks associated with software platforms with a mature ecosystem of users and valued added resellers were utilised to great effect to distribute innovations to potential customers.

There were certainly other forms of collaboration activity undertaken across cases. Several cases developed close associations with research institutions or expert communities to share or acquire knowledge for innovation activity.

6.2.2.3 Information technology capital goods and services

Information technology capital goods and services were acquired as a part of most innovations. If not specifically mentioned in interview transcripts it was apparent in the analyses of field notes or implicit in the design of the innovation.

Notable was the acquisition of information technology capital goods and services that were utilised to configure or develop new information technology goods and services that formed part of the innovation.

Surprising in the data concerning IT capital goods and services was the limited discussion of how innovators utilised or leveraged existing information technologies (those implemented in the organisational contexts). In one case the influence of existing information technology platform was acknowledged as influential. In other cases it was not specifically mentioned in interview transcripts but in reviewing the information technology artefacts involved in the innovation, existing information technologies were undoubtedly involved. In several cases the innovation was actually dependent on pre-existing information technology having been implemented in the organisational context.

6.2.2.4 Domain knowledge

All innovation activities and tasks utilise some form of knowledge to progress the activity. Knowledge of IT development (i.e. knowledge of how to design, develop, assemble, and deploy specific information technologies) was prevalent across all cases. However, the knowledge was not entirely oriented towards the engineering knowledge; so called "soft skill" knowledge, such as requirements analysis and project management, were present and influential in many cases.

Knowledge associated with the area of application for the innovation was also highly important for innovation. This knowledge had to be extracted and codified via the requirements process (formal or otherwise) to allow development to progress.

The merging area of application knowledge and information technology development knowledge was visible and important for innovation activity. The process did not appear linear, rather a back and forth process of development and feedback.

Business administration and marketing knowledge was also present for all but one case involving IT producing organisations. Were it was used it appeared to provide critical support to innovation activities.

6.2.3 Innovation outcomes

The innovations investigated as part of this research resulted in various outcomes in the form of economic, social and technological change. The diffusion and novelty of these innovations varied from context to context and innovators described various issues and challenges they faced obtaining successful outcomes.

Innovators described the specific consequences and outcomes of innovation, but typically a number high-level theme characterised most cases. In nearly all cases innovation introduced changes to organisational resources i.e. the portfolio of assets and capabilities available to organisation(s) from which it could generate commercial benefits or even competitive advantage. Outcomes were generated through time, a characteristic noted across cases for both innovation decisions and innovation activity. Innovations also produced benefits, some planned and others unexpected. Benefits also spanned organisational boundaries and often produced benefits that exceeded initial expectations. Innovation outcomes were also influenced by issues relating to market access, intellectual property and advances in information technology platforms and systems.

Innovation owners were the most influential actors influencing innovation outcomes, but customers, users, developers and suppliers were all shown to have some influence on the outcomes. Industry networks were influential in cases where they were present, whilst research organisations and in once instance a government organisation presented challenges for some organisations trying to realise the benefits of innovation.

Information technology applications and platforms were seen to play a role in innovation outcomes, particularly in the context of developing firm resources (assets). Information technology architecture was also an influential asset for innovation outcomes. Some information technology artefacts helped innovators to overcome various issues and challenges during innovation. Data artefacts also generated unexpected or greater than expected benefits for some innovators.

6.2.3.1 Firm resources

The development or improvement of information technology assets and capabilities were a major outcome of innovation across all cases. In some instances assets were created and placed into operations as part of innovation activities. In other cases information technology production capabilities were created or improved to on sell information technology products or services. In many cases information technology capabilities (developed or improved) were used to deploy the various assets associated with the innovation. For many innovators there appeared to be a cycle whereby area of application knowledge and information technology development knowledge were used as capabilities to generate information technology assets, or improvements in assets or other capabilities.

6.2.3.2 Diachronistic

As discussed in previous sections concerning innovation decisions and innovation activity, the development of innovations were characterised by long-cycles of incremental improvement. As a consequence, innovation outcomes appeared to emerge continuously through time and outcomes were not confined to occur at a particular point in time (synchronic) or at the end of an innovation.

6.2.3.3 Benefits

In all cases innovators self reported achieving economic, social, organisational, or technological benefits as an outcome of innovation. The benefits varied considerably from context to context, some innovators achieved large-scale economic benefits associated with global diffusion of their innovation, where in other cases the innovation was confined to the organisational context for which it was developed. However, for as many benefits that were planned and part of the innovation objectives, there were as many unexpected and unplanned benefits obtained. Several cases produced benefits far exceeding the anticipated benefits that were initially expected.

Innovation benefits were also shown to span organisational boundaries. The realisation of direct benefits (non-externalities) to collaborators appeared common in more than half of the cases investigated. In one instance the innovation lead to a joint venture being formed.

6.2.3.4 Influencing factors

A range of factors appear to influence innovation. Several appeared particularly relevant for the cases investigated in this study. Across all cases the advances in information technology operating platforms and systems had the greatest influence on innovation outcomes. Whilst some advances created challenges for innovators and required change to be implemented during innovation, other advances were major enablers or contributors to innovation outcomes.

Whilst not prolific, several cases involving IT producer organisations cited challenges with intellectual property that ultimately threatened the success of the innovation.

Finally several cases involving IT producer organisations gained access to markets through industry networks. Access to these markets positively influenced innovation outcomes particularly for gaining access to customers and diffusion of the product through related and complementary markets for the innovation.

6.3 A dynamic model of IT innovation

This section generates important insights into IT innovation and presents a dynamic model of IT innovation based on organisational approaches and experiences in IT innovation identified in the findings of the case studies. This model is an evolution of the A-B-C heuristic model grounded in evidence analysed in this thesis.

This section extends the interpretation of the cross-case analysis from the previous section and presents an empirically grounded dynamic model of IT innovation. Key insights provided by this model include – (i) its capacity to explain how regardless of initial motivation to commence IT innovation, the only investments in IT that subsequently evolve into genuine

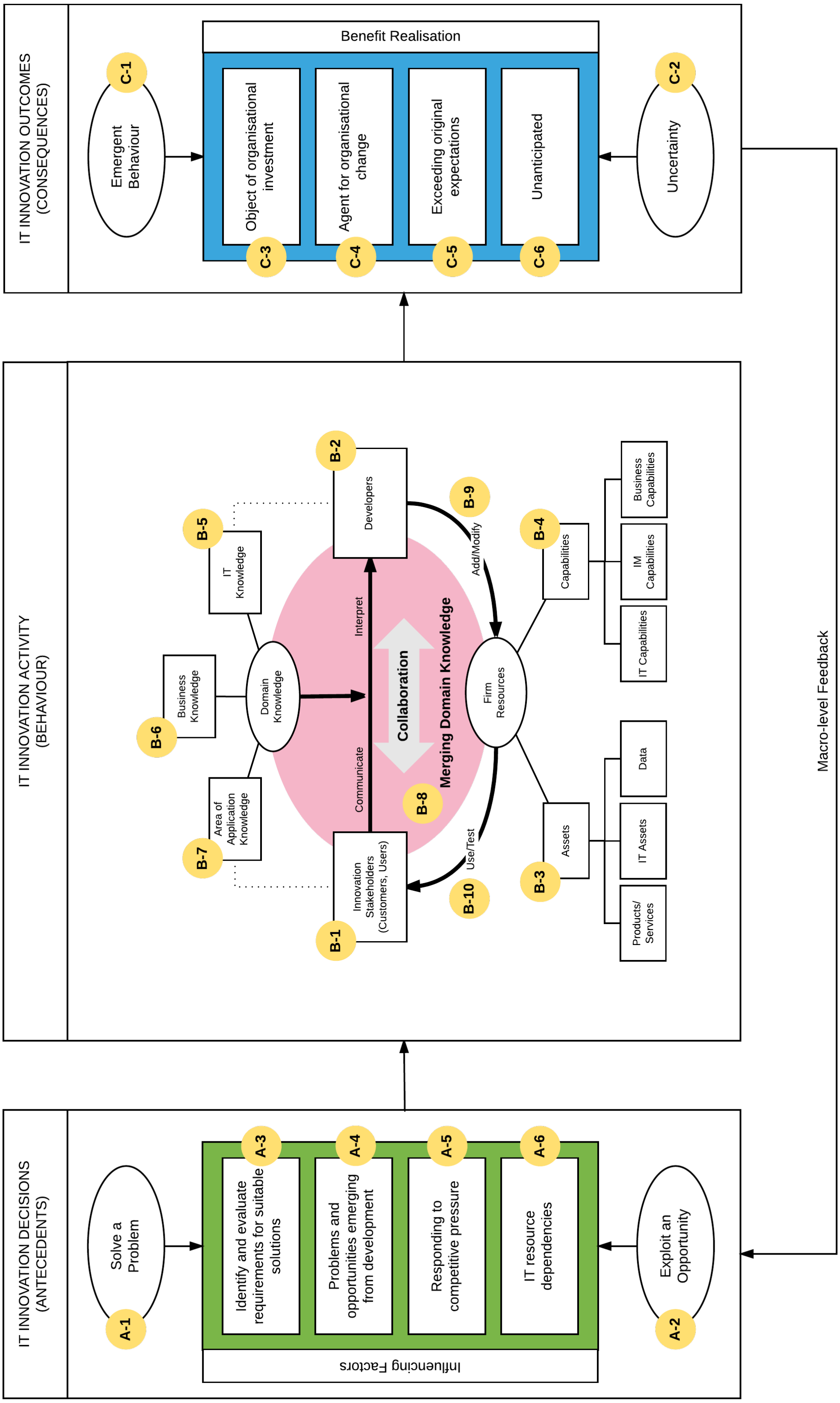
IT innovations appear to be those that are continuously and dynamically modified over time; and (ii) regardless of whether these modifications are formally planned or not, that they evolve organically as a result of stimuli from within or external to the organisation and that uncertainty and emergence are inherent properties of the benefits realisation.

In Section 2.4.3.6 this research highlights the complex nature of innovation and how with complex systems there is ‘a tendency for macro-scale structures and dynamics to emerge spontaneously out of the micro-scale behaviours and interactions of system components’ (Martin & Sunley 2007, p. 6). This model is therefore described and presented in the form of two integrative levels or perspectives (Feibleman 1954), the “micro” and “macro” perspective.

6.3.1 The micro perspective

The micro level perspective of IT innovation is presented in figure 6-1 and is constructed in the form of a traditional behavioural A-B-C feedback model (Brancheau & Brown 1993; Skinner 1938). This model comprises of three subsystems – antecedents, behaviour and consequences, where the antecedents are represented by IT innovation decisions, behaviour are represented by IT innovation activity, and consequences are represented by IT innovation outcomes.

Figure 6-1. Dynamic model of IT innovation practice – micro perspective.



6.3.1.1 IT innovation decisions (antecedents)

IT innovation decision making is the sub-system of the micro based perspective of IT innovation practice and is the antecedent of IT innovation behaviour. IT innovation decisions describe the reasons, motivation, and objectives for undertaking IT innovation.

IT innovation decision-making associated with the nine cases of IT innovation practice involved processes that influenced IT innovation activity and IT innovation outcomes. IT innovation decisions were also influenced by feedback from IT innovation outcomes, a concept described further by the model associated with the macro-based perspective in section 6.3.2.

An important process associated with IT innovation decision-making was the solution search and section process. This process was seen to operate at many different levels, ranging from simple choices through to complex decisions made under conditions of high uncertainty.

Decisions concerning the search and selection of IT based solutions are what differentiate IT innovation decision-making from other types of innovation decision-making. Ultimately, IT solution selection and search involved making decisions about existing IT solutions (in-place and commercial) and their fitness for purpose in terms of fulfilling the IT innovation objectives. It also involved making a decision about the approach and direction of IT innovation activity. For example, would the IT search and selection decision drive IT innovation activity to focus on the development of an IT solution from scratch, or would it seek to integrate and improve an existing solution or perhaps use an existing solution in a new way?

IT innovation decision making was rarely undertaken in any of the cases by a single individual or agent. IT innovation decision making was predominately a collaborative process involving organisational leadership, developers (either internal or external to the organisation), and customers (including users/internal customers). However, the influence of particular stakeholders did vary with the organisational context, and with the different types and levels of IT innovation decision. For example, in many instances of IT innovation operating under conditions of high uncertainty, organisations with a strong entrepreneurial setup had leaders making opportunistic decisions.

Two generic types of IT innovation decision and four important factors influencing IT innovation decisions are also encapsulated in the model of IT innovation practice.

TYPES OF IT INNOVATION DECISIONS:

The nine case studies of IT innovation practice reveal two high-level objectives for IT innovation decisions:

(1) *Solving problems (A-1)* – IT innovation decision-making involves finding solutions to information handling problems. In the context of this research information handling problems pertain to issues associated with the collection, processing, storage and distribution of information. Information technology solutions represent the contemporary approach to solving information handling problems and the range of problems that can be solved with information technology based solutions is diverse.
(2) *Exploiting opportunities (A-2)* – IT innovation decision-making can also involve using the favourable or advantageous conditions created by the development, adoption or improvement of new or improved information technology solutions. Opportunities present themselves either as direct IT based products and services or indirect improvements in other product and services enabled by IT innovation.

IMPORTANT FACTORS INFLUENCING IT INNOVATION DECISIONS:

A range of factors were identified with-in the case studies as influencing IT innovation decisions. Many of these factors were specific to the organisational context. Four factors were either common across all cases or understood to be highly influential in a number of cases:

(1) *Identifying and evaluating requirements for suitable solutions (A3)* – the capacity to identify and evaluate the requirements for IT solutions that are fit for purpose in the context of IT innovation objectives was an important factor in IT innovation decision-making. Understanding the requirements for a given innovation (i.e. what constitutes a suitable solution, and what would actually work) emerged as particularly

challenging issue for many innovators. In place or commercially available solutions were often perceived as imperfect by innovators in the case studies. Decisions concerning the direction and approach to be used for solving problems or exploiting opportunities directly influences IT innovation activity. For any given IT solution, IT innovation activity can take the form of a new bespoke solution development, the modification or improvement of existing solutions, the novel configuration, assembly and use of existing solutions (integration), or a combination of all three modes of IT innovation activity. Further through the IT innovation cycle the extent to which the requirements are identified and evaluated was also seen to impact the next phase or increment of IT innovation decision-making for any given IT innovation, where problems and opportunities could be seen to emerge from the development process.

(2) *Problems and opportunities emerging from development (A4)* – regardless of the selected mode or approach to IT innovation activity found in each of the case studies, new problems and opportunities emerged from IT innovation activity that impacted on IT innovation decision-making. For the case studies, IT innovation activity progressed through a continuous cycle of incremental change aimed at improving the alignment of IT innovation outcomes with the objectives for IT innovation (see the macro-based perspective in section 6.3.2). At the micro level, this process was manifestly interactive. Stakeholders in the form of users, customers, developers and business owners provided feedback relating to the resolution of existing problems, the identification of new problems, and/or the identification of new opportunities. The latter ranging from small incremental improvements and enactments through to wholesale changes in the objectives for IT innovation. Each new problem or opportunity required further IT innovation decision-making.

(3) *Responding to competitive pressures (A-5)* – where IT innovation decisions focused on solving problems or exploiting opportunities, competitive pressures appeared to be an important incentivising factor for the decision to innovate. Competitive pressures arose within the cases from deliberate competitive action or reaction (defence) linked to various commercial strategies. Whilst several cases focused on IT innovation that would position themselves better with established rivals. Others focused on vertical competitive strategies that focused on creating substitute products through IT innovation or establishing new markets with an IT innovation.

(4) *IT resource dependencies (A-6)* – in most cases the IT innovation was dependent on various complementary systems and subsystems. The level of dependency varied considerably across cases. Some innovators were challenged by changes and advances associated with the underlying technologies and other complementary IT assets. This resulted in the emergence of (i) problems that would threaten the chances of meeting the IT innovation objectives; (ii) problems that could impact the continued use of well-progressed innovations; or (iii) opportunities that could improve the benefits or outcomes of IT innovation. Thus decisions concerning IT artefacts such applications, platforms and architectures had implications for IT innovation decision making. Changes in access to human capabilities utilised for IT innovation were also influential for IT innovation decision making. The options available for providing reliable access to domain knowledge such as IT development skills influenced sourcing decisions. Similarly, several innovators required reliable access to business and area of application knowledge.

6.3.1.2 IT innovation activity (behaviour)

IT innovation activity represents the behavioural sub-system of the micro model relating to IT innovation practice across the nine case studies. Innovation activity in this context included activities associated with the design, development and implementation of information technology. IT innovation outcomes were the result of IT innovation activity, where the motivations and objectives for IT innovation activity were driven by IT innovation decisions, and indirectly from the feedback provided about the outcomes from previous IT innovation activity (see the macro-based perspective in section 6.3.2).

For the nine cases studies of IT innovation practice activity was characterised by incremental patterns of design, development, and implementation. Activity typically involved merging domain knowledge and firm resources via a process of collaboration between innovation stakeholders and developers operating towards some set of innovation objectives (formal or otherwise).

The key elements of the model for IT innovation activity emerging from the nine case studies of IT innovation practice were – (1) the agents involved, (2) domain knowledge and (3) firm resources. There are also three important patterns of interaction between these elements also described as part of the model.

THE AGENTS OF IT INNOVATION ACTIVITY:

Agents in the context of the dynamic model of IT innovation are the human actors and decision makers involved with micro level IT innovation activity. Two classes of actor are identified as relevant to the key patterns and activities:

(1) *Innovation stakeholders (B-1)* – actors and decision makers involved with communicating the requirements for IT innovation activity, and testing the results of IT innovation activity. Examples from the case studies of IT innovation practice include users, customers (inclusive of organisational leaders).
(2) *Developers (B-2)* – actors and decision makers involved in the design, engineering, deployment and diffusion of IT innovations. Developers typically created or modified firm assets and capabilities for use by customers or users as part of the IT innovation. Developers included actors such software engineers, business/systems analysts, project managers, change managers, and marketing specialists, Case study data also demonstrated that that is was possible for single person to be both an innovation stakeholder and developer.

An important feature revealed by the case studies of IT innovation practice was that the various agents involved with IT innovation activity where not necessarily confined to a single organisational entity. In fact all nine case studies involved permeable organisational boundaries that facilitated the flow of knowledge and the progress of activity associated with IT innovation through collaborative relationships with external organisations. In particular, the configuration and use of development agents differed considerably between cases. For example, the external sourcing of software engineers was common amongst IT innovation case studies controlled by non-IT producing organisations. Several cases involving IT producing organisations, used developers working within industry networks to facilitate market access and diffusion of the IT innovation.

FIRM RESOURCES – DEVELOPMENT AND INTERACTION:

Firm resources in context the dynamic model of IT innovation describe specific assets and capabilities controlled by the primary innovator that are created, modified, and available for use with respect to IT innovation. The distinction between assets and capabilities within the model is made to clarify differences in the resources and facilitate theoretical caparison during later stages of interpretation.

The case studies of IT innovation practices revealed interaction and development around three common types of asset (B-3):

(1) *Products and services* – commercially distributed assets derived from organisational processes and in the context of this model, generated by or dependent upon IT innovation activity.
(2) *IT assets* – information technology hardware, software and architecture generated or used in IT innovation activity.
(3) *Data* – codified information generated or used in IT innovation activity, with a distinctly digital focus in the context of the case studies.

And three types of capabilities (B-4):

(1) *IT capabilities* – the ability to undertake IT design, development and implementation processes and activities. An example from the case studies would be the ability to conduct software development using a set of standardised methods or techniques.
(2) *Information management capabilities* – the ability to manage the collection, storage, processing, and distribution information and data linked to innovation.
(3) *Business capabilities* – other commercial abilities, financial, marketing, legal, etc. related to IT innovation activity.

Capabilities are distinguished from assets in the context of this model, as being resources with the ability or capacity to coordinate other resources for IT innovation activity.

DOMAIN KNOWLEDGE:

Domain knowledge represents understandings of specific areas of scientific, technological and economic activity. In the context of this model of IT innovation, domain knowledge represents understandings of solutions relating to the problem or opportunities implicit in the IT innovation objectives. Case studies reveal a range of domain knowledge being applied during innovation activity. It is possible to consolidate this knowledge into three high level domains:

(1) *IT knowledge (B-5)* – represents understandings of IT design, development and implementation. IT knowledge is essential for IT innovation and is a key element of IT innovation that distinguishes it from other types of innovation.
(2) *Business knowledge (B-6)* – represents understandings of methods relating good judgment and decision-making associated with operating a business or running an organisation. It includes but would not be limited to management and leadership, commercial decision-making, marketing, human resource, and financial literacy.
(3) *Area of application knowledge (B-7)* – encapsulates the understandings associated with the industry sector(s), functional area or environment where the IT innovation is to be implemented. Area of application knowledge typically includes methods, processes, rules, and routines associated with information handling that are to be supported or embodied within an IT innovations.

The sources of domain knowledge utilised for IT innovation activity varies with the socio-technical IT innovation context. Specific organisational or technological contexts influence the sources of knowledge required for IT innovation activity. For example, the cases associated with IT producing organisations are seen to have greater access to internal IT domain knowledge but often need to seek out areas of application knowledge. Similarly most cases of IT innovation involving non-IT producing organisations often source external IT domain knowledge.

IMPORTANT PATTERNS OF INTERACTION:

There are several patterns of interaction identified within the case studies of IT innovation practice that appear common, important or influential for IT innovation activity. For the cases under study IT innovation activity appears to involve three interactive mechanisms that combine domain knowledge with new and existing IT assets and capabilities, facilitate IT innovation outcomes, and create a platform for continuous innovation. The discrete mechanisms involved in these interactions are:

(1) *The merging of domain knowledge (B-8)* – innovation stakeholders collaborate with developers by communicating their knowledge of the IT innovation requirements to the developers. Developers interpret these requirements and use their understanding of that domain knowledge in combination with their IT domain knowledge to undertake IT innovation activity (e.g. design, development, implementation, etc).

(2) *The use, creation, modification, and improvement of firm resources (B-9)* – using the requirements interpreted from the domain knowledge, developers utilise, create, modify, and/or improve the pool firm resources. For example, developers may create new IT systems (IT assets) that can be used in processes that support the production of goods and services (product and services assets). In a different IT innovation scenario, developers might adopt a new software development methodology (IT capability) to coordinate the production of software products and services (product and services assets).

(3) *The testing and feedback of IT innovation activity (B10)* – IT innovation stakeholders, particularly the users and customers of IT innovation outcomes, provide testing and feedback (formal or otherwise) to the developers and other innovation stakeholders in regards to the quality and performance of the outcomes of IT innovation activity. Quality in the context of this model is taken to be the suitability or aptness for purpose with respect to the desired area of application for resources created, modified, or improved as part during IT innovation activity. Feedback from testing usually takes the form of (i) faults, including failure to meet the quality and performance criteria; (ii) suggested enhancement, improvements or changes in the scope of the quality and performance criteria. Testing can be formally or informally undertaken as operational use by innovation stakeholders.

There are also two important characteristics evident for these mechanisms of IT innovation activity within the case studies:

(1) Interactivity – 'collaboration' between innovation stakeholders and developer across the mechanisms is distinctly interactive. It is not a linear stepped through workflow but a two-way interaction that can be initiated by stakeholders or developers.
(2) Continuous incremental development – IT innovation activity is influenced by the continuous incremental nature of IT innovation (see the macro-based perspective in section 6.3.2). Thus processes are ongoing through the lifecycle of IT innovation and the mechanisms that combine domain knowledge with new and existing IT assets and capabilities create platforms for continuous innovation.

6.3.1.3 IT innovation outcomes (consequences)

The consequences of IT innovation decisions and IT innovation activity are described in this model as IT innovation outcomes. IT innovation outcomes typically took the form of socio-technical change within the case study organisations. The results of these changes are described within this model in terms of the benefits realised from IT innovation activity. It is acknowledged that not all changes contribute to innovation success, albeit difficult to extract detail information on innovation failures. In fact an innovation that fails is arguably not an innovation at all. Instead the model describes some of the challenges experienced by several cases.

IT innovation is a complex, dynamic and emergent phenomenon. IT innovation outcomes are subject to uncertainty, with the benefits IT innovation often being unanticipated and/or exceeding original expectations. This fluidity relates directly to how decisions, activities and behaviours iteratively evolve during the innovation process and how this influences the realisation of benefits. IT innovation is both an object of organisational investment and an agent of organisational change, in a manner that tends to be non-linear, organic and/or unpredictable.

THE BENEFITS REALISED FROM IT INNOVATION OUTCOMES:

IT innovation outcomes and the benefits associated with IT innovation activity varied considerably from context to context. Some innovators achieved large-scale economic benefits associated with global diffusion of their innovation. Other cases achieved significant change confined to the organisational context for which it was developed. Across the cases of

IT innovation practice there were four main characteristics associated with the benefits realised from IT innovation outcomes:

(1) IT innovation as an *object of organisational investment (C-3)* – A primary benefit derived from IT innovation outcomes was the investment in IT assets and capabilities that could then be either commercialised as new products and services or employed to generate improvements in other firm resources.
(2) IT innovation as *agent of organisational change (C-4)* – implicit in the definition of innovation is the notion of improvement or change. For many cases a key benefit of IT innovation the agency that IT assets and capabilities provided in relation to other firm resources in the context of organisational change. For example, IT innovation outcomes produced changes in the way other resources performed or could be utilised by the innovating organisation. In several cases IT innovation facilitated changes in the behaviour or nature of relationships between social actors within an organisation or market.
(3) Benefits *exceeding original expectations (C-5)* – IT innovation outcomes often exceeded the expectations or the objectives originally set for the IT innovation. In some instances extended benefits were achieved through a process of continued improvement during the life cycle of the IT innovation. In other instances extended benefits were achieved due to unanticipated effects of the innovation when placed into operation or use. Innovation outcomes where also seen to span organisational boundaries. The realisation of direct benefits (non-externalities) to collaborators appeared common in more than half of the cases investigated.
(4) Outcomes *yielding unanticipated results (C-6)* – The emergent properties of IT innovation yielded outcomes that could not be anticipated or predicted. For as many benefits that were planned and part of the innovation objectives there were as many unexpected and unplanned benefits obtained. In several cases the unanticipated outcomes became the main focus of IT innovation moving forward through its life cycle.

INHERENT PROPERTIES ASSOCIATED WITH BENEFITS REALISATION:

Uncertainty and emergence are inherent properties of the benefits realisation that had important implications for the case studies of IT innovation practice:

(1) *Uncertainty (C-2)* – the case studies of IT innovation practice demonstrated that there were difficulties predicting or forecasting the outcome of IT innovation activity. For the cases under study this took the form of uncertainty about the requirements, and uncertainty about the technological approach. For example, user or customer requirements were often incomplete or unavailable for a specific IT innovation objectives such as IT innovations designed future customers. Developers could not be completely certain if their designs would meet the needs of potential customers. Similarly where the developer was employing unproven or completely novel information technology configurations to achieve the IT innovation objectives, there would be a high degree of uncertainty about the quality of the solution. These types of uncertainty influenced managerial thinking and subsequent approaches to IT innovation decision-making and IT innovation activity. In some cases experimental research and development approaches were applied to stage outcome delivery to minimise the risks of failure or adverse consequences. In other cases, entrepreneurial leadership was prepared to accept uncertainty and progress IT innovation activity along a specific trajectory with less rigorous control of the delivered outcomes. Both approaches lead to successful IT innovation outcomes for the cases under study.

(2) *Emergence (C-1)* – IT innovation outcomes emerged from a process of interaction between innovation stakeholders and developers, using domain knowledge and firm resources to produce IT innovations. In many cases IT innovation decisions and IT innovation activity were undertaken with specific objectives in mind. Where those objectives were met, IT innovation outcomes were somewhat predictable, albeit something novel and new emerged. However, for many cases IT innovation outcomes where qualitatively different than expected, where outcomes exceeded expectations or realised unanticipated results. For the cases under study unpredictable results from IT innovation activity contributed to further IT innovation outcomes.

FACTORS INFLUENCING IT INNOVATION OUTCOMES:

Several factors were seen to influence IT innovation outcomes for the cases under study. The diffusion and novelty of these innovations varied from context to context, and innovators described various issues and challenges they faced obtaining successful outcomes as follows:

- Industry level advances in information technology operating platforms, systems and development techniques had a significant impact on IT innovation outcomes. For some innovators these advances were a key enabler for success, opening up new opportunities or new methods of solving problems. For others they represented a challenge, where change was required to maintain existing systems dependencies or to remain competitive.
- Several cases involving IT producer organisations gained access to markets through industry networks. Access to these markets positively influenced innovation outcomes, particularly for gaining access to customers and diffusion of the product through related and complementary markets for the innovation.
- Issues with intellectual property rights also presented challenges for a few innovators. Interestingly they were not addresses or reviewed until considerable IT innovation activity had progressed.

6.3.2 *The macro perspective*

For the nine cases studies of IT innovation practice, the micro level perspective described in section 6.3.1 shows how IT innovation emerges from diverse sets of inter-relationships within and between individual and organisational decisions, activities and behaviours relating to information technology. It also suggests that IT innovation is intimately associated with the development and improvement of IT assets and capabilities and the capacity to leverage domain knowledge in conjunction with those IT resources. The micro level perspective encapsulates an iteration or increment of IT innovation.

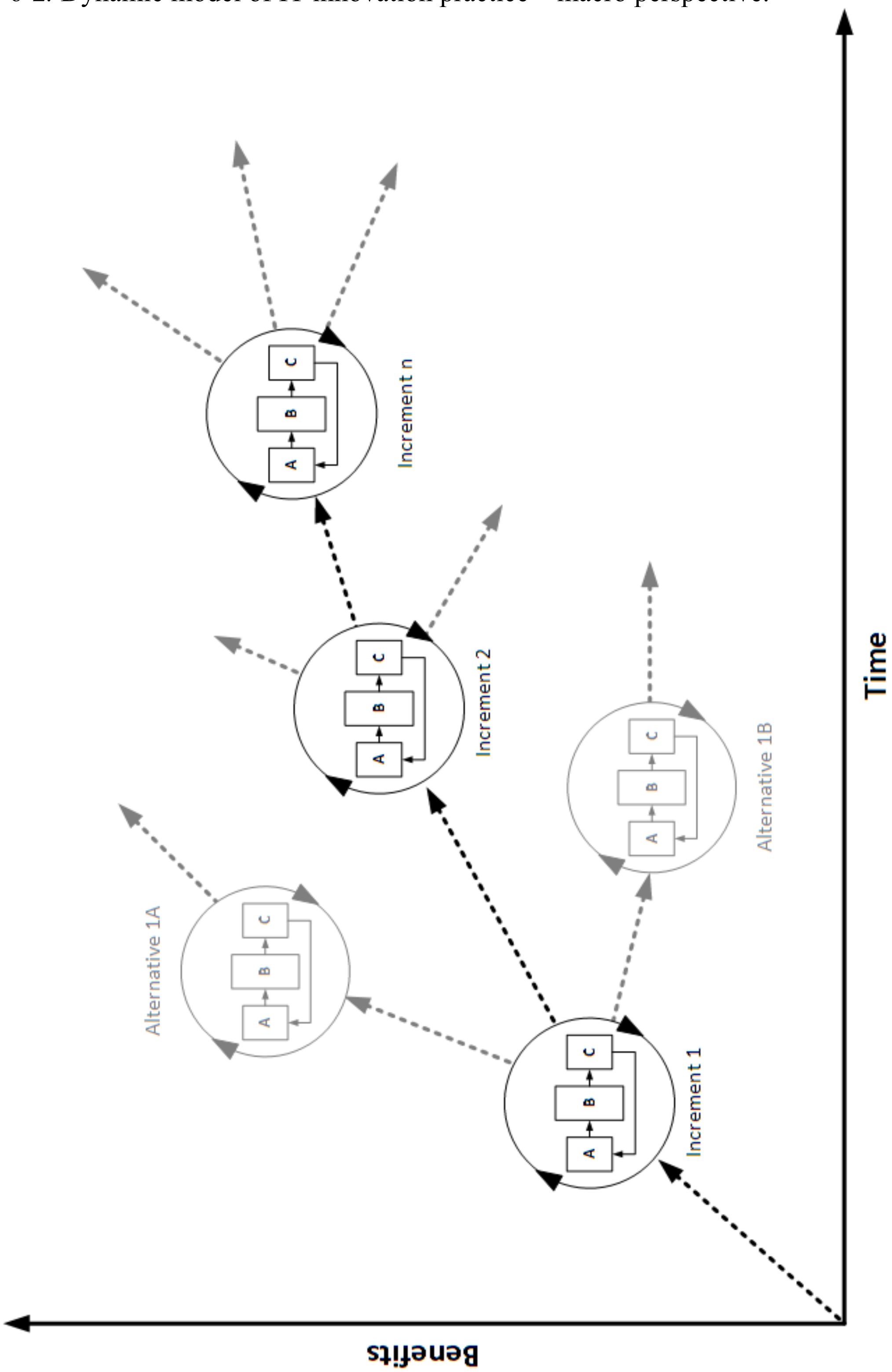
The macro level perspective of IT innovation is presented in figure 6-2 and describes how each iteration or increment of IT innovation is part of a broader continuous and dynamic cycle of benefits realisation through the lifecycle of an IT innovation.

The key elements of this model are as follows:

(1) IT innovations have a lifecycle.
(2) IT innovations are continuous, but characterised by phases, increments, and/or iterations.
(3) Benefit realisation is non-linear, heterogeneous and sometimes delayed.

(4) New problems and opportunities emerge from the feedback of each phase, increment or iteration.

Figure 6-2. Dynamic model of IT innovation practice – macro perspective.



IT INNOVATION LIFECYCLES

IT innovation is a continuous and dynamic cycle of benefits realisation that transitions through the lifecycle of the IT innovation. Albeit there are different rates of IT innovation progress, the case studies of IT innovation practice indicate that IT innovations transition through a lifecycle of varying innovation activity from intensive research and experimental development, operational use and eventually decline. However, IT innovation activity appears to continue, even during the decline.

CONTINUOUS PHASED INCREMENTAL DEVELOPMENT

IT innovation is continuous throughout its lifecycle but characterised by phases, increments, and iterations. Each phase, increment or iteration involves the development and improvement of IT assets and capabilities with the technology artefacts developed and continuously integrated, cycling through phases of (A) IT innovation decision-making, (B) IT innovation activity and (C) IT innovation outcomes.

BENEFITS REALISATION

The benefits associated with IT innovation occur throughout the lifecycle of an innovation, however they are subject to heterogeneity in terms of their type and impact. For example, benefits resulting from IT innovation activity may flow continuously throughout the life of an IT innovation, but the benefits realised during one phase, increment or iteration may have significantly more, or a different type of outcome for an organisation. There is also the prospect of dis-benefits or non-benefits emerging from a phase.

The benefits associated with IT innovation emerge at different rates. Some IT innovations produce highly successful outcomes in short time frames, whilst others take time to realise substantial benefits. This was none the more apparent in the case study data where some cases took many years to realise significant benefits, whilst others produced resounding business outcomes in less than a few years. What is apparent from the case study data is that IT innovation benefits are not simply produced or manufactured, rather they to emerge from extended periods of IT innovation decision making and activity.

The rate of benefit realisation from IT innovation also appears to be non-linear. The heterogeneous nature and timing of the benefits means that IT innovations move along a path where the cumulative benefits realised over time are somewhat variable. This study did not seek to measure a rate of benefits realisation but data from the case studies revealed that IT innovation varied (i) across cases, and (ii) changed at different points in time for a given case.

FEEDBACK

IT innovation appears to be contingent on individual and organisational knowledge of the impact and benefit the IT innovation at a specific point in time. Feedback resulting from internal and external stimulus during each phase, increment or iteration allows new problems and opportunities to emerge, thus innovation continues on a dynamic path.

6.4 Discussion: Enfolding the literature for IT innovation

In this section existing theory is revisited in the context of the findings and dynamic model of IT innovation linked to the nine case studies of IT innovation practice. This analysis is then used as the foundation for developing a knowledge framework to modify and extend understandings of IT innovation in Section 6.5. The use of prior theory towards the end of a study, during the analysis and interpretation phases is advocated by Eisenhardt (1989b) and described as enfolding the literature (Section 3.3.2.5). This process is consistent with the principle of dialogical reasoning that seeks sensitivity to contradictions between the findings of this research and theory found within literature (Klein & Myers 1999).

The role of existing theory in the context of this research is discussed in Chapter 3. Prior theory relating to IT innovation was initially summarized and presented in the context of information systems research and innovation theory in Chapter 2. This review was used to justify the study and identify research issues and problems associated with IT innovation.

Reflecting on the research questions and findings associated with the nine case studies of IT innovation practice the proceeding section outlines important empirical considerations associated with – the definition of IT innovation, IT innovation typologies, the reasons and objectives for IT innovation, the outcomes and benefits of IT innovation, how IT innovation happens, and factors of success associated with IT innovation.

6.4.1 Revisiting definitional issues

A number of important research streams exist within the IT/IS literature that deal with the development, implementation and use of information technology, however IT innovation is rarely defined or explored in its own right. Kwon and Zmud (1987) suggest that information systems (IS) implementation is a form of technological innovation, describing it as the 'organisational effort to diffuse and appropriate information technology within a community of users' (Kwon & Zmud 1987, p. 231). Swanson (1994) describes IT innovation as an 'innovation in the organizational application of digital computer and communication technologies'. Both of these and other examples from the IT/IS literature describe IT innovation within the context of organisational diffusion and adoption (Fichman 2004; Lucas, Swanson & Zmud 2008).

Descriptions of IT innovation within the IT/IS research domain are dominated by diffusion and adoption research (Fichman 2004). This research has strong links with organisational and behavioural theories such as those found in Rogers (1962) diffusion of innovations theory and the Technology Acceptance Model (TAM) outlined in Davis, Bagozzi and Warshaw (1989). Chapter 2 outlines various criticisms directed at these theories in the context of IT development. Fichman (2004) highlights the contributions of this research but also emphasises that IT innovation research needs to move beyond diffusion and adoption to further understand what may be important dimensions IT innovation.

Contemporary definitions of innovation found within innovation theory describe innovation as 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations' (OECD/Eurostat 2005, p. 46). The term innovation is also used interchangeably to describe both the process of introducing something new and the outcome of introducing something new (an innovation).

Innovation theory has long discussed the relationship between invention, innovation and diffusion in the context of technological change. Schumpeter (1934) argued that technological change was a process where new technology entered the marketplace through three stages of development: (1) invention – the act of conceptualising new ideas or designs;

(2) innovation – putting ideas and designs into practice; and (3) diffusion – the broader use and adoption of the innovation (Jaffe, Newell & Stavins 2002).

Significant in the context of the diffusion and adoption found within the existing IT/IS literature, innovation researchers have observed that the continuous nature of most technological change tends to blur the boundaries between the processes of invention, innovation and diffusion, with many innovation activities spilling into the invention and diffusion stages (Freeman 1991; Rosenberg 1976; Ruttan 1959). It is not possible to have diffusion and adoption without invention (Hall 2005). Recent definitions of innovation acknowledge the co-dependent relationship between invention, innovation, and diffusion and tend to encapsulate all three stages of development over indefinite timeframes to provide a more inclusive, albeit broader definition of innovation (Kline & Rosenberg 1986; Rosenberg 1976).

The dynamic model of IT innovation relating to the findings associated with the nine case studies of IT innovation practice, depict and describe IT Innovation as complex system of interacting processes, agents and artefacts, where information technology is the object of investment or an agent for change that can be used to solve information handling problems, or exploit opportunities that arise from the development, or use of information technology. These findings support the observations found in innovation theory that see innovation processes interacting closely with processes associated with invention and diffusion. This also provides a potential pathway beyond the important but overtly dominant diffusion-based perspectives of IT innovation that pervades the existing IT/IS literature.

6.4.2 Different types of IT innovation

Within the innovation literature definitions for innovation invariably extend into classification schemes describing different types of innovation. Various innovation classification methods exist within the innovation literature that work across a number of characteristics and dimensions of innovation. There are also very specific and specialised schemes that are useful for making comparisons within particular industry or functional sectors.

For the study of innovation as a phenomena in its own right, it is common to differentiate between four basic types of innovation – product, process, marketing, and organisational innovation (OECD/Eurostat 2005). There are also a number of classification schemes that differentiate innovation in terms of its novelty and impact, classifying innovations as radical or incremental, or a derivative of such. Such classifications have proven problematic, with some researchers questioning the distinction between radical and incremental. Silverberg and Verspagen (2005) argue that all innovation is fundamentally incremental. If the term radical innovation is to be accepted, this has also been shown to be subject to a range of interpretations within the literature (see Chapter 2). Garcia and Calantone (2002) see novelty and impact operating at both the market and technological level. Garcia and Calantone (2002) propose that radical innovations are those that create new markets or technological discontinuities, where incremental innovations are those that introduce improvements into existing technologies used in existing markets.

Despite the issues with novelty and the impact based differentiation of innovation, the concept is pervasive within the IT/IS domain, albeit to some extent using different terminology e.g. disruptive and sustaining innovation (Christensen 1997). Carlo, Lyytinen and Rose (2011) describe two ways of classifying IT innovations. The first is based on content or what one is innovating with. The other is based on the nature or radicalness of the innovation, which is inturn linked to the originality and uniqueness (novelty) of innovation outcomes.

The content category of IT innovation is an adaption of an initial scheme for classifying organisational IS innovations developed by Swanson (1994). This scheme was subsequently refined by Lyytinen and Rose (2003) and then simplified by Carlo, Lyytinen and Rose (2011) to comprise of three types or areas of IT innovation:

- Base IT innovations – changes in the core systems, platforms and infrastructure.
- Process innovations – changes in technical and supporting administrative processes. For example changes in development tools, methods, teams and their structure.
- Service innovations – the development of new technical and business solutions for customers and users.

The nature of IT innovation category described by Carlo, Lyytinen and Rose (2011) is a derivative of the novelty and impact based differentiation scheme. This category proposes that IT innovations exist on a scale ranging from incremental to radical, and that the basis for classification is how the innovator perceives the innovation in terms of its originality and uniqueness (novelty).

Important in the context of Carlo, Lyytinen and Rose (2011) is the notion that disruptive IT innovations can emerge from radical IT innovations when radical innovation occur across all three types of IT innovation content. Carlo, Lyytinen and Rose (2011, p. 95) describe disruptive IT innovation as IT innovation where the 'effects are transformative and path-breaking, and that they start to strongly influence the future IT innovation direction'. Carlo, Lyytinen and Rose (2011) empirically test the effects of radical IT innovation across the different types of IT innovation and found that base IT innovation influenced service innovation, and that base IT innovation and service innovation together influenced process innovation. At this point it should be acknowledged that the concept of disruptive innovation used by Carlo, Lyytinen and Rose (2011) varies from that originally specified in Christensen (1997) and subsequently emphasised in Christensen, Raynor and McDonald (2015) as being market breaking rather than technologically radical. Despite the differences, Carlo, Lyytinen and Rose (2011) provide an important contribution to understanding the dynamic nature IT innovation.

Reflecting on the observations and findings associated the dynamic model of innovation derived from the nine case studies of IT innovation practice two issues emerge in support and contradiction of existing theory.

First, whilst the four general types of innovation (product, process, marketing, and organisational innovation) commonly used in innovation research are inherently useful for comparing innovations across sectors, they appear to have limited utility in describing IT innovations. The modified Swanson (1994) classification scheme provided by Carlo, Lyytinen and Rose (2011) provides clearer alignment with the dynamic model of IT innovation derived from the case studies. It also provides greater insight into the type of innovation activity that may be undertaken in comparison to the more general typology. The dynamic model of IT innovation associated with the case studies of IT innovation practice also provide an opportunity to revisit and reframe the terminology to be representative of an

IT innovations impact and/or influence upon firm resources. For example, IT base innovation would be associated with the development and improvement of IT assets; process innovation would be associated with development and improvement of IT capabilities, IM capabilities and business capabilities; and service innovation would be associated with development and improvement products and services, either IT products and services or other products and services with IT resource dependencies.

Second, reservations emerge concerning the polar relationship between radical and incremental innovation. General arguments against this distinction in the sense of novelty and diffusion have some support in the innovation literature (Silverberg & Verspagen 2005). Observations and findings from the case studies show a profoundly incremental approach to IT innovation. Furthermore incremental IT innovations in several of the case studies exhibit the novelty and diffusion characteristics associated with radical innovations, and several cases would also pass the criteria for a disruptive IT innovation defined by Carlo, Lyytinen and Rose (2011). Thus the concepts of radical and disruptive IT innovations appear valid in the sense they can be found in IT innovation practice, however it would appear that radical and disruptive IT innovation are part of a broader mechanism of incremental IT innovation. When initially conceptualising the model of disruptive IT innovation (Lyytinen & Rose 2003, p. 581) concluded that ‘disruptive IT innovation is only a preliminary step towards a more encompassing dynamic theory of IT innovation’.

The importance and relevance of radical and disruptive IT innovations described in Carlo, Lyytinen and Rose (2011) should not be completely dismissed. The case study observations and findings integrated into the dynamic model of IT innovation support interaction between the different types of IT innovation activity comparable to base, process and service IT innovations.

6.4.3 IT innovation drivers

Concepts relating to the reasons and objectives (drivers) of IT innovation are not well covered in the IT/IS literature beyond the inherent lure of the potential benefits associated with IT investment. Information technology’s inherent potential for technical improvement provides significant opportunity for it to be directly involved in innovation activity and makes it an attractive proposition for innovators (Brynjolfsson & Saunders 2010). Innovation theory on the other hand, provides greater insight into what the drivers of IT innovation might be. The Oslo Manual (OECD/Eurostat 2005, p. 19) proposes that the drivers for innovation are relate to ‘products, markets, efficiency, quality or the ability to learn and to implement changes’. ABS (2014) suggests that the drivers for innovation relate to – profit; competition, demand and markets; production and delivery i.e. increasing efficiency, quality or capabilities; reduction of environmental impacts; improvement in safety or working conditions; responding to government regulations; and adherence to standards.

Findings associated with this study and the dynamic model of IT innovation practice propose there are two high level objectives associated with IT innovation decisions:

(1) Finding solutions to problems associated with the collection, processing, storage and distribution of information (solving problems); and
(2) Exploiting opportunities associated with favourable or advantageous conditions created by the development, adoption or improvement of new or improved information technology solutions.

Whilst it is important to focus on the types of activities and outcomes of IT innovation there is a propensity to overlook the reasons and objectives for IT innovation. Identifying the innovation objective(s) for IT innovations may facilitate greater understanding of differences associated with methods, processes and IT resources across the two high level categories of IT innovation objectives.

6.4.4 IT innovation processes

The processes of innovation, IT or otherwise are covered differently by the IT/IS literature and innovation theory. The contemporary view of the innovation within the innovation literature is that it is dynamic and emergent process, best represented as complex system rather than a linear or staged process model. Within the IT/IS literature the best approximation of an innovation process is encapsulated by understandings of IT development and implementation. These processes are generally expressed as activity oriented lifecycle models. Generic examples include software development methodologies, project management processes and benefits realisation management frameworks. Recently, there has been an increased recognition of interactive and adaptive process models that are more closely related to the systems based approaches advocated by innovation theory (Avison & Fitzgerald 2006). One possible reason IT development and implementation processes are represented in such a manner, may be due to the applied nature of the information systems discipline and the professional and engineering culture that has a traditionally codified the building and development of systems through formalised processes and procedures.

Innovation studies and research involving innovation systems in many cases address research issues at the organisation level or above. Whilst there are specialised studies that explore innovation within organisations and around specific research issues, theory is oriented towards explaining generalised concepts of innovation. This is perhaps not unexpected and it is undoubtedly the objective of innovation research, however it does not provided a detailed understanding of IT innovation.

The dynamic model of IT innovation generated from observations from the case studies describes a system of emergence and self-organisation (Martin & Sunley 2007), where macro-scale structures and dynamics are proposed to emerge out of the micro-scale behaviours and interactions of various system components (See Section 2.4.3.6). The notion of higher and lower order perspectives (macro and micro) in the context of technological innovation systems is also supported by Rosenberg (1994) and Arthur (2009).

From a *macro perspective*, findings from the case studies of IT innovation practice and the dynamic model of IT innovation propose that IT innovations have a lifecycle, and that a continuous and dynamic cycle of outcomes transition through the lifecycle of an IT innovation. Similar concepts are supported within the early innovation adoption literature. Rogers (1962) and Bass (1969) for example provide a widely accepted diffusion and adoption lifecycle model. Whilst this model is subject criticism across the recent literature, it is still notionally accepted as a high level construct for viewing innovation lifecycles. Lifecycle concepts, including the use logarithmic style s-curve distributions of effort over time are also common within the project management discipline (PMI 2000). There are also a number of lifecycle models accepted within the information systems literature in the context of strategic information systems management (Galliers & Sutherland 1991; Nolan 1973), along with various incarnations of the systems development lifecycle (Boehm 1988) and the adaptive agile methods (Cervone 2011; Highsmith & Cockburn 2001).

Innovation is seen as continuous through its lifecycle. However, in the case study findings it is characterised by incremental iterations that give rise to different rates of benefit realisation that are subject to internal and external feedback relating to the outcomes of each iteration, or from changes in the external environment.

Socio-technical perspectives of technology development possibly provide a complementary view of these lifecycle phenomena. For example theory associated with the social construction of technology (SCOT) advocate that various technology development pathways or trajectories are socially constructed (Bjiker, Hughes & Pinch 1987). More precisely SCOT proposes that technology development progresses via a negotiated process directed by various interests and knowledge of the participating actors (Olsen & Engen 2007). The implications for IT innovation under this model would potentially see micro level socio-technical interactions drive the formation of various (possibly multiple) development paths where each iteration is a temporary stabilisation or rejection of a problem or opportunity solved.

Many of the behaviours described above are also typically covered within complexity theory, per the characteristics highlighted by Martin and Sunley (2007) described in detail in section 2.4.3.6.

A great portion of this study involved a detailed *micro level analysis* of the activities and behaviours associated with IT innovation practice. The dynamic model of IT innovation generated from the case studies highlighted the role of domain knowledge, the development and use of firm assets and capabilities, and collaboration within and across organisational boundaries.

A key insight from the dynamic model of IT innovation generated from the case studies was that whilst IT innovation followed a general process of design, development and implementation, for any iteration the actual tasks and nature of interaction within that process varied considerably across firms. Brooks (1987) provides an interesting perspective on this, indirectly arguing that the methods used to solve IT development problems are less relevant (in terms of contribution to outcomes) than the influence of solving the problem. In other words the problem itself is likely to be a key contributor to the activities undertaken by innovators.

The model does however identify three common interactive patterns or mechanisms associated with or embedded within these processes: (i) the merging of different types of domain knowledge i.e. IT knowledge, IM knowledge and business knowledge; (ii) the creation, modification and improvement of firm assets and capabilities (resources); and (iii) testing activities that produced internal feedback from development and innovation outputs.

For the dynamic model of IT innovation, the mechanism of merging domain knowledge is an interactive process between innovation stakeholders and developers primarily concerned with translating business or area of application knowledge in the form of requirements so it can be combined with technical domain knowledge, ultimately producing new or modified IT assets and capabilities. This type of knowledge management is well supported in the IT/IS literature (Newman & Robey 1992) and the likelihood of IT/IS implementation success has been shown to increases with the quality of designer-user interaction (Kwon & Zmud 1987). Wang and Ramiller (2009) also highlight the form and diversity to which the merging of domain knowledge can occur within an innovation community emphasising the role of acquiring new, or modifying and reinforcing existing IT knowledge, through community interaction.

Similarly the innovation literature acknowledges the importance of knowledge use and management for innovation. The Oslo manual (OECD/Eurostat 2005) emphasises the influential nature of interactive working relationships between innovation stakeholders, suppliers and customers. It also highlights how external domain knowledge can be embodied in machinery or equipment. There is additional support for the same concept within the IT/IS literature, linking the merging of domain knowledge with the development or improvement of IT assets and capabilities, where domain knowledge is ultimately embodied in the IT resources and utilised for or forming part of IT innovation (Baetjer 1997; Leonard-Barton 1992).

The second and related mechanism identified in relation to the micro level perspective is the use, creation, modification and improvement of firm resources, or more specifically how domain knowledge is combined with existing assets and capabilities to generate IT innovation in the form of new or improved IT assets and capabilities. The foundational theoretical backing for this process is the resource based view of the firm (Barney 1991) that proposes the assets and capabilities controlled by an organisation enable the organisation to improve its efficiency and effectiveness e.g. thorough innovation.

The resource-based view has also been utilised within the information systems literature to explain the value of information technology (Wade & Hulland 2004). Research has also examined the interaction of information technology with other resources (Powell & Dent-Micallef 1997). Clemons and Row (1991) argue that information technology creates competitive advantage by leveraging or exploiting pre-existing human and business resources. Human resources in this context refer to tacit domain knowledge where business resources are the other assets and abilities controlled by an organisation. Amit and Schoemaker (1993) describe assets as tangible and intangible inputs that can be used in the organisations production process, whereas capabilities are defined as the ability to deploy those assets into productive use. Bharadwaj (2000) presents a modified scheme of information technology resources – information technology infrastructure; human information technology resources; and information technology enabled intangibles (customer orientation, knowledge assets, synergy across business functions). The role of IT assets is also discussed in further detail in the proceeding section 6.4.6.

There is also underlying support for the continuous operation of the resource creating mechanism described in the dynamic model. Teece, Pisano and Shuen (1997) emphasises the importance of the firm’s ability to develop and reconfigure resources in rapidly changing competitive environments known as dynamic capabilities. Wade and Hulland (2004) argue that IT resources share many of the attributes associated with dynamic capabilities.

The final mechanism described for the micro level perspective were activities that provided feedback or testing for the outputs of development and innovation. IT innovation stakeholders such as users and customers provide feedback (formal or otherwise) to developers and other innovation stakeholders in regards to the quality and performance of IT innovation outputs. For the dynamic model of IT innovation generated by the case studies this feedback usually comprised of faults and suggestions for enhancement or improvement.

The verification and testing of design and development outputs, has long been recognised as important within IT/IS theory and practice. Activities associated with the evaluation of output and system quality (Delone & McLean 2003) and technology acceptance (Davis, Bagozzi &

Warshaw 1989) have been highly influential within the software engineering and the IT/IS implementation literature (Boehm 1988). The need for IT innovation stakeholders to share information relating to the fitness for purpose of IT innovation outputs has contributed to the changes in various systems development methodologies (Leffingwell & Widrig 2000). It also appears to have been a particularly important driver for the adoption agile development and project management techniques (Highsmith & Cockburn 2001). Very little attention is paid to the detailed micro-level analysis of this within the innovation literature outside of accepting that innovation is a linked and interactive process.

For commercial product and services innovation market responses also play a role in feedback. Having a close working relationship with customers in this context has been shown to be influential in commercial software development initiatives (Segelod & Jordan 2004). Disruptive innovation has also been argued in this context (Christensen 1997) testing design variations for customers of incumbent product and services markets that have effectively overshot some customers needs (Yu & Hang 2010).

The two roles are not exclusive and IT innovation where IT is the output of IT innovation activity is rare without an IT resource input[4]. Similarly, IT resources can be used to coordinate and facilitate outcomes that do not have IT resources as a significant output.

6.4.5 IT innovation stakeholders

An important assumption associated with this research is that IT innovation occurs within a complex socio-technical environment. This assumption is also supported within the IT/IS literature (Avgerou 2001; Lee, AS 2001). Socio-technical theory is also regularly integrated into innovation theory to explain innovation activity and innovation cooperation (Geels 2004; Williams & Edge 1996). Tuomi (2002, p. 15) argues ‘innovation can only be understood by studying the social basis of innovation’.

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[4] One exception may be using IT knowledge to put an IT capability into practice.

Observations from the case studies of IT innovation practice highlight a range of participants or stakeholders operating within various social structures in relation to IT innovation. The analysis presented in Chapters 4 and 5 identified and consolidated various roles and social structures involved in IT innovation into higher-level archetypes. The following observations were made in relation to the social structures:

(1) Innovation decisions where often influenced by entrepreneurial innovation business owners or leadership. Customers, users and developers also appeared to have varying degrees of input into innovation decisions.
(2) Innovation activity was undertaken by or with customers, users, developers, innovation owners/leaders, and suppliers. Senior leadership commonly directed the IT innovation activity. Where industry networks were involved, they were influential. Less common within the cases but also having impact were activities involving government, research institutions, and incubators.
(3) Innovation owners/leaders were the most influential for IT innovation outcomes, however customers, users, developers, and suppliers were all shown to have influence on IT innovation outcomes. Again, where industry networks were present they were influential, whilst interacting with research intuitions and government organisation presented a challenge for several organisations trying to realise the benefits of innovation.

The importance of individual actors or agents is highlighted in both the IT/IS implementation literature and innovation theory. The IT/IS implementation literature places a significant emphasis on the role of individuals in the adoption and diffusion of information technology (Davis, Bagozzi & Warshaw 1989). Von Hipple (2005, p. 1) emphasises the role of users in the innovation process and agues the process of 'user-centred innovation processes are very different from the traditional, manufacturer-centric model, in which products and services are developed by manufacturers'. Von Hippel (2005) outlines two distinguishing characteristics for users that innovate – (1) that they have leading edge knowledge of an important market or technology trend; and (2) that they perceive high returns (benefits) in obtaining a solution to their needs.

User-centred perspectives of IT design and development are also pervasive within the IT/IS literature, albeit the theory has moved on through two different eras of computing. During the personal computing revolution that started in the 1980s researchers grappled with the newfound opportunities provided to end-users for development and adoption of information technology (Brancheau & Brown 1993). Now in the era of pervasive Internet based computing information technology IT consumerism is at a peak. The development and improvement of new technology is now heavily influenced by user-centred innovation (Harris, Ives & Junglas 2012). User-centred innovation from a consumer perspective was not present in the cases and is potentially a gap that requires additional focus in data collection moving forward.

The role of organisations and relationships between organisations are also highlighted in the IT/IS implementation research and innovation theory. An important concept within innovation research is the idea that innovation occurs within innovation systems. Innovators are understood to operate within institutional systems or ecosystems, collaborating with customers, competitors, and suppliers often using common infrastructures and learning systems (Ediquist 2005; Tushman 1977). Ediquist (2005) defines the main constituents of an innovation system as (1) organisations, the formal structures or actors involved in innovation; and (2) institutions, standard routines, methods or rules that regulate interactions and behaviour between and within organisations.

The influence of government, research and related institutions is emphasised by King et al. (1994). The institutional interventional model and the six forms of institutional action (King et al. 1994) described in Chapter 2 provide a method for describing institutional intervention associated with IT innovation.

The concept of an IT ecosystem is discussed in Chapter 2 in relation to Iansiti and Richards (2005). The main actors described for the system are:

- Platform providers are those who develop and provide the systems from which other systems and technologies are based.
- Partners are those who develop applications for and systems for users and consumers.
- IT Users/Consumers are those who use and consume the applications, products and services.
- Research institutions and knowledge networks that provide access to scientific and technical knowledge.

Further distinctions and classifications are also possible from the literature. Organisations can be classified in terms of their primary business activities. In the context of IT innovation this comprises of IT producers and non-IT producers. The IT producing sector comprises organisations or firms that primarily produce information technology goods or services. The IT user sector on the other hand, comprises organisations or firms that utilise information technology as part of their operations. Whilst they do not produce information technology goods and services as their primary activity, the production or development of information technology goods and services is certainly not precluded.

It is possible to further break down IT producers into three quite different classes or categories. The well established IT producers and the custodians of successful IT platforms and mainstream applications (Big-IT); those who modify or improve applications and platforms (Value Added Intermediaries); and those working with new concepts and technologies (Start-ups).

It has also been demonstrated that great proportion of IT development occurs outside of the IT producing sector within the IT-user sector (Smith 2002, 2005; Smith, O'Brien & Jerrim 2007). Case study observations also demonstrate that new IT producers can occasionally emerge from innovations initially undertaken by IT user sector businesses.

IT innovation systems have been seen to vary from country to country and region to region (Altenburg & Lundvall 2009). The implications of this being that the regional context of IT innovation is likely to be important in terms of the type and extent of interaction between organisations.

An important observation revealed in the case studies of IT innovation practice was that the various agents involved with IT innovation activity where not necessarily confined to a single organisational entity. The flow of knowledge and the acquisition of technology across different collaboration organisations are well documented in the Management and IT/IS literature. Merali (2002) and later Clarke (2005) introduce the role of permeable organisation boundaries in the context of knowledge management and collaboration. Clarke and Turner (2003) suggest an extension of traditional resource based theory due to the importance of resources utilised beyond the organisational boundary, arguing resources connected via permeable boundaries have the potential to competitive advantage.

Collaboration with external agents can be vertical and horizontal (OECD/Eurostat 2005). Organisations extend vertically up and down the value chain though customers and suppliers and horizontally through competitors, researchers and like-minded organisations.

Reflecting on the cases of IT innovation practice and the model of dynamic IT innovation, agents within the model are the human actors and decision makers involved with micro level IT innovation activity. Classification of those actors was consolidated towards two classes – innovation stakeholders and developers. The high-level distinction was seen to be most relevant for the patterns and activities that emerged from the cases and formed part of the model. The characteristics and dimensions of this classification scheme are consistent with much of the literature, although the literature concerning permeable boundaries and links to resources associated with permeable boundaries should be further acknowledged. For example, the diffusion of software as a service (SaaS), platforms as a service (PaaS) and infrastructure as a service (IaaS) exemplify the notion of services operated externally as resources.

6.4.6 Sources of knowledge for IT innovation

The Oslo manual (OECD/Eurostat 2005) emphasises the influential nature of interactive working relationships between innovation stakeholders, suppliers and customers. It also highlights how external domain knowledge can be embodied in machinery or equipment. There is additional support for the same concept within the IT/IS literature, linking the merging of domain knowledge with the development or improvement of IT assets and capabilities, where domain knowledge is ultimately embodied in the IT resources and utilised for or forming part of IT innovation (Baetjer 1997; Leonard-Barton 1992).

Through innovation processes, new and existing knowledge is routinely incorporated into products, processes and services (Popadiuk & Choo 2006). Knowledge is often combined with technology to create innovations either as new knowledge and technology, new uses or combinations of existing knowledge and technology. Technologies in themselves are essentially the embodied knowledge of a productive process (Baetjer 1997).

The dynamic model of IT innovation generated from the case studies of IT innovation practice emphasise that IT innovation is part asset exploitation and development (also see

Section 6.4.7), but also part knowledge exploitation and development. The model defines three types of domain knowledge that is relevant to IT innovation – IT knowledge, business knowledge and area of application knowledge.

- *IT knowledge* – understandings of IT design, development and implementation. IT knowledge is essential for IT innovation and is a key element of IT innovation that distinguishes it from other types of innovation.
- *Business knowledge* – understandings of methods relating good judgment and decision-making associated with operating a business or running an organisation. It includes but would not be limited to management and leadership, commercial decision-making, marketing, human resource and financial literacy.
- *Area of application knowledge* – encapsulates the understandings associated with the industry sector(s), functional area or environment where the IT innovation is to be implemented. Area of application knowledge typically includes methods, processes, rules and routines associated with information handling that are to be supported or embodied within an IT innovations.

Knowledge of information technology development i.e. knowledge of how to design, develop, assemble and deploy specific information technologies was unsurprisingly prevalent across all cases. However, the knowledge was not entirely oriented towards the engineering knowledge, "soft skill" knowledge such as requirements analysis and project management were present and influential in many cases.

Knowledge associated with the area of application for the innovation was also highly important for innovation. This knowledge had to be extracted and codified via the requirements process (formal or otherwise) to allow development to progress.

The merging of area of application knowledge and information technology development knowledge was visible and important for innovation activity. The process did not appear linear, rather a back and forth process of development and feedback.

Business administration and marketing knowledge was also present for all but one case involving ICT producing organisations. Were it was used it appeared to provide critical support to innovation activities.

For the dynamic model of IT innovation, the mechanism of merging domain knowledge is an interactive process between innovation stakeholders and developers primarily concerned with translating business or area of application knowledge in the form of requirements so it can be combined with technical domain knowledge, ultimately producing new or modified IT assets and capabilities. This type of knowledge management is well supported in the IT/IS literature (Newman & Robey 1992) and the likelihood of IT/IS implementation success has been shown to increases with the quality of designer-user interaction (Kwon & Zmud 1987). Wang and Ramiller (2009) also highlight the form and diversity to which the merging of domain knowledge can occur within an innovation community emphasising the role of acquiring new, or modifying and reinforcing existing IT knowledge, through community interaction.

6.4.7 The role of firm resources in IT innovation

Information technology artefacts are inherently configurable and programmable, to the extent that they are routinely adapted and modified for a wide range of use. They are in effect a general-purpose solution for problems and opportunities involving the collection, processing, storage and distribution of information.

The economics and innovation literature describe a class of technologies known as general-purpose technology (GPT) that has the capacity to open up a wide range of possibilities for further innovation across different domains or industry sectors (Bresnahan & Trajtenberg 1995; Freeman 1991). There is a consensus across different research domains that information technology exhibits many if not all of the characteristics of a GPT. Bresnahan and Trajtenberg (1995) outline to two important characteristics of a GPT. First is that they have inherent potential for technical improvement, and the second is that they facilitate innovation complementarities.

Information technology's inherent potential for technical improvement provides significant opportunity for it to be directly involved in innovation activity, and makes it an attractive proposition for innovators (Brynjolfsson & Saunders 2010).

When Bresnahan and Trajtenberg (1995) referred to innovation complementarities it was largely from a macro-economic perspective, referring to the downstream sectorial impacts of technology diffusion throughout an economy. However, innovation complementarities also exist at the micro-level, where the interaction between IT assets and other organisational resources has been shown to be highly significant and one of the most beneficial outcomes of information technology investment (Brynjolfsson & Hitt 1998).

The innovation complementarities associated with IT investment are outlined in Chapter 2, but outcomes have been shown to vary considerably from organisations to organisation and appear to influenced by the configuration and alignment of unique factors within the organisational context (also known as firm-effects). The implications of this for this research are that IT innovation outcomes are contingent upon the availability and capacity to exploit complementary resources.

The dynamic model of IT innovation associated with the case studies of IT innovation practice highlights general-purpose nature of IT assets. Continuous incremental IT innovation exploits the flexibility of IT assets to be modified and improved. The dynamic model of IT innovation generated by the case studies describes a continuous and interactive resource utilisation, improvement and creation mechanism interacting with three common types of organisational assets:

- *Products and services* – commercially distributed assets derived from organisational processes and in the context of this model, generated by or dependent upon IT innovation activity.
- *IT assets* – information technology hardware, software and architecture generated or used in IT innovation activity.
- *Data* – codified information generated or used in IT innovation activity, with a distinctly digital focus in the context of the case studies.

The model also highlights three important capabilities:

- *IT capabilities* – the ability to undertake IT design, development and implementation processes and activities. An example from the case studies would be the ability to conduct software development using a set of standardised methods or techniques.
- *Information management capabilities* – the ability to manage the collection, storage, processing, and distribution information and data linked to innovation.

- *Business capabilities* – other commercial abilities, financial, marketing, legal, etc. related to IT innovation activity.

Within this model, capabilities are distinguished from assets as being resources with the ability or capacity to coordinate other resources for IT innovation activity.

Information technology is also used in innovation that does not involve IT as the primary output or outcome (Smith, O'Brien, & Jerrim, 2007). Observations from the cases studies of IT innovation practice see IT resources being both an input to IT innovation activity and an output of IT innovation activity. IT resources can be used as an input for IT innovation activity, either acquired as capital goods or operational services, or employed from the existing pool of IT resources. Alternatively, IT resources become the object or outcome of IT innovation. The innovator develops, modifies or assembles (combines) various IT resources to produce new IT resources that are the primary outcome if IT innovation. The two roles are not exclusive and IT innovation where IT is the output of IT innovation activity is rare without an IT resource input[5]. Similarly, IT resources can be used to coordinate and facilitate outcomes that do not have IT resources as a significant output.

In several cases IT assets are modified and deployed for completely different purposes than originally intended. The capacity for IT assets to be combined with other firm resources in a dynamic fashion is also a key element of the dynamic model IT innovation derived from the case studies. Conceivably the firm effects could be linked to how the organisation conducts IT innovation, how it makes IT innovation decisions, how it combines domain knowledge with the portfolio of assets and capabilities the firm has at its disposal to generate new assets and capabilities through a process of diffusion and feedback.

Notably IT resources conceivably influence IT innovation in the sense that it is both an object of investment and an agent of change. Some IT innovations invest in IT innovation to produce direct outcomes based on IT resources e.g. a software artefact. Alternatively or in

[5] One exception may be using IT knowledge to put an IT capability into practice.

conjunction with the production of IT resources, some IT innovations use IT resources to facilitate changes in other organisational resources to produce indirect IT innovation outcomes.

6.4.8 The outcomes and benefits of IT innovation

The IT/IS literature does not look specificity at the outcomes and benefits associated with IT innovations, but there is a significant body of knowledge that looks at the value of IT investments. This literature is reviewed in Chapter 2. A particularly relevant synopsis of this literature is provided by Kohli and Grover (2008) who argue that the value of IT investment is both real (financial) and perceived, and that this value is created in conjunction with complementary resources; manifested in many ways and at different levels; capable of creating competitive advantage (with some limitations); latent and often not immediate, lags behind the initial investment for some time; and is ultimately difficult to measure.

Innovation research has taken a more generalised and arguably economic approach to understanding innovation outcomes. Innovation can be viewed as an increase the quality of economic activity (West 2009), where improvements in quality indirectly lead to a greater benefits and/or the avoidance of cost associated with specific economic activities. At the macro level this can translate to an increase in economic output and ultimately economic growth. At the micro level it has the potential improve the competitiveness of an organisation within its industry group or sector, increase revenue thorough the sales of improved products and services or reduce costs through improved processes and organisational change (OECD/Eurostat 2005).

Survey work undertaken in the Australian business context (ABS 2014) show that most organisations benefitted as a result of innovation and that the main benefits were (1) improved customer service, (2) increased revenue, (3) gaining a competitive edge, or (4) achieving a reduction in costs.

Observations from the case studies of IT innovation practice see innovators setting objectives for IT innovation and mostly achieving them. Notable characteristics relating to the outcomes and benefits of IT innovation taken from the case studies and reflected in the dynamic model of IT innovation are:

- The heterogeneity of benefits.
- Outcomes are uncertain and sometimes unexpected.
- Benefits often exceed expectations but sometimes take longer to emerge than anticipated.
- IT innovation can be an investment or an agent of change.

The case study data suggest that IT innovation benefits are not simply produced or manufactured, but rather they to emerge from extended periods of IT innovation decision making and activity. The benefits realised from IT innovation are also different in terms of their nature and timing. The differences are not only across cases, but also within cases. For a single case the benefits realised during one phase of innovation can be different in terms of the nature and timing to the next.

6.4.9 Influential factors for IT innovation

Four factors are identified to be influencing IT innovation decisions within dynamic model of IT innovation derived from the case studies – (1) the ability to identify and evaluate requirements for suitable IT innovation solutions; (2) problems and opportunities emerging from development (including the initial set of problems and opportunities); (3) responding to competitive pressures (market forces) and (4) the impact of changes in relation to IT resource dependencies (both constructive an unhelpful).

The IT/IS literature focuses heavily on factors that facilitate the adoption and diffusion of IT innovations (Fichman 2004). These factors are important and are well covered in the IT/IS literature.

Kwon and Zmud (1987) provide an early but highly relevant consolidated framework for early IT/IS research that links IS implementation to technological innovation through the application of theories of organisational change. This framework describes various factors organised within a modified version of Leavitt (1965) diagnostic model. The applied model comprises of Leavitt (1965) original forces task, technology, structure and people with the addition of environmental factors. Detailed reviews of the various factors are provided in Chapter 2. These factors are consistent with the methods used to develop the dynamic model of IT innovation associated with the case studies outlined in Chapter 3.

Other researchers have since focused on individual factors associated with user and technology acceptance Davis, Bagozzi and Warshaw (1989); Delone and McLean (1992, 2002); Venkatesh et al. (2003); Wixom and Todd (2005) to provide evaluative frameworks for IT/IS implementation success.

Davis, Bagozzi and Warshaw (1989) introduced a behavioural model, the Technology Acceptance Model (TAM) that proposed that individual adoption and use of information technology was linked to perceived usefulness and perceived ease of use whereby there was also an intermediary link between intention to use and actual system use. TAM has been subsequently tested and extended by researchers.

In a similar manner Delone and McLean (1992) introduced a model of IT/IS implementation success that agued information quality and system quality influenced user satisfaction and intention to use that, in turn, influenced organisational outcomes. Later extensions of this theory by the IS research community provided additional feedback paths relating to use and user satisfaction derived from benefit realisation. Delone and McLean (2002) revised model is highly relevant to elements of the micro perspective in the dynamic model of IT innovation associated with the case studies. The process of benefits realisation and adoption being progressed as part of feedback process associated with the use and satisfaction with the benefits is consistent with the case derived model for IT innovation.

There are also broader studies of IT/IS implementation following the diffusion of innovation (DOI) theory set out by Rogers (1962). This research is summarised in Chapter 2, however there are numerous adaptions and application of DOI theory within the IT/IS implementation literature. So much to the extent that IT/IS implementation research has and still remains highly fragmented along the lines of new factors and mediating variables that are arguably contextual and environmentally driven (Lucas, Swanson & Zmud 2008).

Innovation theory also deals factors associated with success and failure of innovation at a general level. Van der Panne, Van Beers and Kleinknecht (2003) undertook an extensive review of the innovation literature relating to commercial and technological viability of new product innovations. This review argues that various factors can be grouped into firm related, project related, product related and market related factors.

Maidique and Zirger (1984) ague that there is no single magical factor that can explain innovation success or failure and reflecting on contemporary theories of innovation it is possible to see why this may be the case. For example, the uncertainty associated with innovation outcomes and decisions means that it is possible for innovators to take a different course of action to achieve the same outcomes (Nelson & Winter 1977). Thus it is entirely conceivable that different factors of success are likely apply in each case. Innovation is also very complex. There are often a range of unique characteristics and dimensions associated with innovation within a specific industry, sector, or area of application (Rosenberg 1994).

An alternative but pervasive view of IT innovation from within the IT producer sector is the notion that success that can be generated by radical or disruptive IT innovations. Mentioned previously in section 6.4.2, disruptive IT innovations are IT innovations that have a significant impact on markets Christensen, Raynor and McDonald (2015), where radical innovations are the result of technological progress and typically have a transformative and path breaking effect on the future direction of IT innovation (Carlo, Lyytinen & Rose 2011). From an IT/IS implementation success perspective Carlo, Lyytinen and Rose (2011) argue that IT innovation that changes or causes disruption to base IT resource dependencies can have a significant impact on IT other types of IT innovation and innovation outcomes in general.

Increasing returns (benefits) from development and modification of IT resources are also identified within the case studies. There are also instances where IT resource dependencies have a negative or problematic effect upon IT innovation activity. Some of the problems associated with IT resource dependencies were the result of disruptive IT innovations that were generated externally, or limitations associated with technology architectures in the context of the problem or opportunity at hand. These problems appeared to be profoundly historical and technologically path dependent. The concept of path dependency is discussed in the context of innovation in Section 2.4.3.4.

6.5 A knowledge framework for IT innovation research

In the preceding sections of this chapter an empirically grounded model of IT innovation involving multi-case analysis of IT innovation practice was presented and used to structure the key findings associated with this research. The model and associated findings were then interpreted and discussed in the context of the existing literature, looking for similarities, differences and gaps in current theory. Based on the interpretation and discussion, this section presents a knowledge framework designed to extend existing understanding of organisational approaches and experiences in IT innovation. This provides guidance for future case study research on how to reveal the mechanisms and processes that contribute to dynamically determining what IT innovation is, how IT innovation is achieved, and how IT innovation can be analysed effectively. The knowledge framework is presented at a slightly higher level of abstraction than the model in Section 6.3 and is designed to be used by practitioners and researchers to explore cases of IT innovation. The knowledge framework is organised in to three distinct areas of guidance relating to the definitional, investigative and theoretical foundations of IT innovation:

- The definitional guidance provides a contemporary definition for IT innovation along with its important characteristics and dimensions.
- The theoretical guidance outlines the important theoretical foundations of IT innovation from the existing IT/IS literature, innovation and related theories. It also incorporates theory developed in by the study.
- The investigative guidance provides a recommended approach level for investigation IT innovation phenomena.

Table 6-1. Knowledge framework for investigating IT innovation

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
<u>Defining IT innovation</u>		
	Innovation is a key component of technological change. Schumpeter (1934) describes innovation as putting ideas and designs into practice. There are however a wide range and variety of definitions for innovation within the innovation, economics and management science literature. A precise definition for innovation drawn from innovation literature describes innovation as 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations' (OECD/Eurostat 2005). IT innovation is rarely defined in the IT/IS literature (Thurley & Turner 2013). Swanson (1994) provides one of the few discreet definitions of IT innovation proposing that IS innovation is 'the organisational application of information technology … that may involve a new IS product or service, a new IS work technology or a new IS administrative arrangement'. Findings from this study suggest that Swanson (1994) definition reflected notions of IT innovation closely related to innovation theory at the time of the research and that it followed similar use and combination theory provided by several earlier researchers (Kwon & Zmud 1987). Lyytinen and Rose (2003) and later Carlo, Lyytinen and Rose (2011) attempt to introduce new concepts from the general innovation literature exemplifying the evolving nature of IT innovation itself. The definition provided by this study reflects the dynamic and evolving nature of IT innovation and argues it should be viewed as a complex system working around IT artefacts and social structures.	The definition of IT innovation is evolving with the technological phenomena that underpin it. It is also being shaped by the context to which it is being deployed. IT innovation is therefore dynamic. This study also suggests that IT innovation is both an object of investment and agent of change. To address the dynamic and multifaceted nature of IT innovation an the implications this has for defining IT innovation it is recommended that researchers view IT innovation as a complex and emergent system rather than a process or output of innovation activity. This study proposes the flowing contemporary definition, but accepts it will change with future research: *IT Innovation is complex system of interacting processes, agents and artefacts where information technology is the object of investment or an agent for change that can be used to solve information handling problems, or exploit opportunities that arise from the development or use of information technology.* This study looks at organisational approaches to IT innovation, but this context in itself varies quite considerably. For example the way "Big IT" views IT innovation may be quite different than a small IT start-up would conceive it. Defining ITR innovation needs to be sensitive to diversity in context. Also complicating this diversity are changes in what influences organisations and markets competing with IT innovations. Social and consumer market phenomena now pervade IT innovation thinking where previously it was the domain of the organisational users. What's more organisational users are themselves being influenced by social and consumer based IT innovation.

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
Types of IT innovation		
	The innovation literature provides many different typologies for innovation. The generic typology that has been used for firm level research in OECD countries classifies innovation as product, process, marketing or organisational innovation. This scheme has been shown to have significant utility for measuring innovation across different sectors of the economy and been used to provide economy wide comparisons of innovation (OECD/Eurostat 2005). There are also numerous classification schemes that classify innovation in terms of the novelty and impact (Abernathy & Clark 1985; Christensen 1997; Freeman & Soete 1997; Henderson & Clark 1990; Porter 1985; Tushman & Anderson 1986). Kalbach (2015) matrix depicting these schemes along dimensions of technological progress and market impact is a useful representation for such schemes. Within the IT/IS literature Swanson (1994) developed a typology for IS innovation based on a similar model by Daft (1978) used within the organisational innovation literature. Lyytinen and Rose (2003) and then Carlo, Lyytinen and Rose (2011) introduce an extended version of Swanson (1994) typology to incorporate the technological an market impact perspectives. Lyytinen and Rose (2003) introduce the disruptive innovation terminology into the IT/IS literature. This and subsequent literature using the disruptive terminology have arguably struggled to maintain consistency with Christensen (1997) original concept. This study updates Swanson (1994) and Carlo, Lyytinen and Rose (2011) typology with contemporary theory and observations from the case studies of IT innovation practice.	Classifying IT innovations can provide researchers with a useful method for (a) compassion with other forms of innovation across sectors and industries; or (b) providing improved understanding of what activity and outcomes relate to the IT innovation under study and how best to further analyse it. For research objectives that require measurement and comparison across sectors and industries, the generic innovation classification framework – product, process, making and organisational innovation as provided in the Oslo Manual (OECD/Eurostat 2005) is recommended. The utility of this scheme lies with its broad scale use in many studies of innovation. For research that requires in-depth understanding of IT innovation phenomena it is recommended that the updated classification scheme developed within this study by utilised. This updated scheme included the following classifications: • IT base innovation – the development and improvement of IT assets. • IT related process innovation – development and improvement of IT capabilities, IM capabilities and business capabilities. • IT related product and service innovation – development and improvement products and services, either IT products and services or other products and services with IT resource dependencies. The updated IT innovation classification can also be integrated with Kalbach (2015) matrix to gain greater understanding of the types of change involved with IT innovation. The classification of IT innovations as being disruptive is also cautioned, researchers are encouraged to review and evaluate the specific definition and use of the terminology provided in Christensen, Raynor and McDonald (2015).

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
IT innovation drivers		
	Information technology's inherent potential for technical improvement provides significant opportunity for it to be directly involved in innovation activity and makes it an attractive proposition for innovators (Brynjolfsson & Saunders 2010). However the reasons and objectives for why organisations innovate with IT are not well covered in the IT/IS literature. Within the innovation literature the objectives for innovation are considered to relate to 'products, markets, efficiency, quality or the ability to learn and to implement changes' (OECD/Eurostat 2005). Findings associated with this study and the dynamic model of IT innovation practice propose there are two high level objectives associated with IT innovation decisions: (1) Finding solutions to problems associated with the collection, processing, storage and distribution of information (solving problems); and (2) Exploiting opportunities associated with favourable or advantageous conditions created by the development, adoption or improvement of new or improved information technology solutions.	Identifying the innovation objective(s) for IT innovations may facilitate greater understanding of differences associated with methods, processes and IT resources used for IT innovation. It is recommended that researchers focus understanding the reasons and objectives for IT innovation. Awareness of the two high level objectives for IT innovation generated by this research may assist in this process. Experience conducting this research also demonstrated that the reasons and objectives for IT innovation can change, because they are part of a cycle of incremental feedback and response on a micro scale, and in the longer term part of lifecycle of innovation decision making on a macro scale. Thus researchers should be aware that there are different types, levels and stages of objectives that can be accessed utilising the heuristic model used in this research. This heuristic model recommends that data collection and analysis be sensitive to the antecedents, behaviours and consequences of IT innovation in the form of IT innovation decisions, IT innovation activity and IT innovation outcomes respectively. The heuristic model is first outlined in Section 2.5 of this thesis and then further elaborated in the dynamic model of IT innovation in Section 6.3.
IT Innovation Processes		
	The processes of innovation, IT or otherwise are covered differently by the IT/IS literature and innovation theory. The contemporary view of the innovation within the innovation literature is that it is a dynamic and emergent process, best represented as complex system rather than a linear or staged process model (Kline & Rosenberg 1986). Within the IT/IS literature the best approximation of an innovation process is encapsulated by understandings of IT development and implementation. These processes are traditionally expressed as activity oriented lifecycle models. Generic examples include software development methodologies,	Reflecting on the two approaches taken by the different research domains, investigators looking at IT innovation processes should be aware that computer science and software engineering, along with IT/IS implementation practice have strong ties to the engineering discipline. As a consequence procedurally driven methods and processes have, and still remain an important institution for IT/IS development practice. For this reason alone, researchers should not expect to see linear methods or conceptualisations of IT innovation processes disappear from the thinking and orientation of IT innovation activity. Even when interactive and adaptive techniques are employed, linear conceptualisations of the

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	project management processes and benefits realisation management frameworks. These activity models have been institutionalised in IS theory and practice. In recent years IT development practice and IS theory has begun to move closer to the systems based approaches advocated in innovation theory. Interactive and adaptive process models have become commonplace for software development and similar methods are starting to diffuse into IT/IS implementation and project management practices. (Avison & Fitzgerald 2006). Brooks (1987) provides an interesting perspective on the role of methodologies, indirectly arguing that the methods used to solve IT development problems are less relevant (in terms of contribution to outcomes) than the influence of solving the problem. Findings from the case studies and the dynamic model of IT innovation practice generated by this research provides some insight into the different processes and mechanisms that are routinely played out as part of IT innovation. As outlined in Section 6.3 the dynamic model is conceptualised at two different levels – macro and micro. In this sense macro-scale structures and dynamics are proposed to emerge out of the micro-scale behaviours and interactions of various system components (See Section 2.4.3.6). The notion of higher and lower order perspectives (macro and micro) in the context of technological innovation systems is also supported by Rosenberg (1994) and Arthur (2009). The macro level model is characterised by an IT innovation lifecycle where incremental iterations that give rise a continuous and dynamic cycle of outcomes and benefits, that are subject to internal and external feedback relating to either the outcomes of each iteration, or changes in the external environment. Similar concepts are supported within the early innovation adoption literature. Rogers (1962) and Bass (1969) for example provide a widely accepted diffusion and adoption lifecycle model. Whilst this model is subject criticism across the recent literature, it is still notionally accepted as a high level construct for viewing innovation lifecycles. Lifecycle concepts, including the use logarithmic style s-curve distributions of effort over time	processes and methods are likely to be presented as a means of explanation. One possible method for integrating this perspective into current theory is to use this perspective as the institutional component of an IT innovation system, possibly the most suitable being the functional approach advocated by Carlsson and Jacobsson (1997). The functional approach is recommended for investigating IT innovation because it emphasises the dynamic nature of innovation systems and highlights the importance of the entrepreneur and micro-level innovation activity (Hekkert et al. 2007). Discussions with those involved with IT innovation in the context of systems development methodologies is also likely to yield more information on IT innovation processes. Finally Brooks (1987) augment in its own right provides guidance for those investigating IT innovation. Brooks (1987) position in the context of software development is that there is ‘no silver bullet’ to be found in software development methodologies. He suggests the problem itself is likely to be a key contributor to the type and order of activities undertaken by innovators. Reflecting on the above, the following recommendations are provided for researchers in relation to investigating IT innovation processes: • Adopt a systems based perspective of IT innovation and the conception of IT implementation and development processes as institutions as part of a ‘functional systems of innovation’ approach as advocated by Carlsson and Jacobsson (1997). • Reflect on the theories associated with emergence and self-organisation (see also Feibleman (1954) integrative levels) when examining dynamic processes. • Collecting and analysing data about IT innovation over extended time periods. • Seek to understand the nature of IT innovation problems and objectives in order to understand the processes and activities. Also be sensitive to how the problem and objectives can change over time.

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	are also common within the project management discipline (PMI 2000). They are also widely accepted within the IT/IS literature in the context of strategic information systems management (Galliers & Sutherland 1991; Nolan 1973) along with various incarnations of the systems development lifecycle (Boehm 1988) and the adaptive agile methods (Cervone 2011; Highsmith & Cockburn 2001). Continuous and dynamic change transposed with feedback and stimulus are also characteristics highlighted by much of the literature on complexity (see Martin and Sunley (2007) as described in section 2.4.3.6). The micro level model identifies three common interactive patterns or mechanisms associated with or embedded within these processes: (1) the merging of different types of domain knowledge i.e. IT knowledge, IM knowledge and business knowledge; (2) the creation, modification and improvement of firm assets and capabilities (resources); and (3) testing activities that produced internal feedback from development and innovation outputs. The first and third patterns are often present in most IS development methodologies. The second is covered in more detail in the previous section of this framework and supported in much of the resource based theory literature found within IT/IS literature and elsewhere. The dynamic model of IT innovation generated from the case studies of IT innovation practice suggest that interactive and adaptive process are playing an important role in IT innovation, however they appear to be working in concert with the institutionalised phased lifecycle perspectives that have been a part of the IT/IS domain for some time. An alterative explanation may also be that the IT/IS discipline is attempting to incorporate and institutionalise the emergent and complex nature of IT innovation in traditional ways.	• Look closely at the three development mechanisms drawn from case study model – the merging of domain knowledge, creating, improving and utilising IT resources, and testing and feedback relating to IT innovation outcomes, to see if they remain relevant and useful for describing IT innovation activity
<u>IT innovation stakeholders</u>		
	An important assumption associated with this research is that IT innovation occurs within a complex socio-technical environment. This assumption is also supported within the IT/IS literature (Avgerou 2001; Lee, AS 2001). Socio-technical theory is also regularly integrated into innovation theory to explain innovation activity and innovation cooperation (Geels 2004;	The utility of understanding the actors and social structures associated with IT innovation is highlighted in the methodology used to conduct this study. At the most fundamental level identifying who is involved in IT innovation allows the researcher to identify potential sources of information relating to IT innovation decisions, activity and outcomes. At a broader level it allows

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	Williams & Edge 1996). Tuomi (2002) argues, 'innovation can only be understood by studying the social basis of innovation'. Observations from the case studies of IT innovation practice demonstrate a range of participants or stakeholders operating within various social structures in relation to IT innovation. Findings from the case studies also highlight – how the role and importance of specific agents change through various increments or cycles of IT innovation; that organisational boundaries are often permeable with IT innovation activity spaning multiple organisations; how IT innovation appears to vary in subtle ways when comparing IT producers and IT users. The notion of who gets involved in innovation is well covered within the innovation literature under the umbrella theory innovation systems. A central theme of this research is that 'innovation and diffusion of technology is both an individual and a collective act' (Hekkert et al. 2007). One of the main constructs of an innovation system are the formal structures or actors involved in innovation i.e. individuals and organisations (Ediquist 2005). The role of the entrepreneur is also an important in foundational component of innovation theory. Innovation studies and the systems of innovation literature, with the exception of functional approaches (Carlsson & Jacobsson 1997), have largely focused on the organisation as the unit of analysis or subject based approach (Smith 2005). However the permeable organisational boundaries and systemic nature of IT innovation observed in the case studies suggest there is scope for a functional or object based approach for IT innovation. King et al. (1994) institutional interventional model and the six forms of institutional action provide a potential method for describing institutional intervention associated with IT innovation. Like innovation theory the IT/IS literature also looks at the role of organisations and individuals in terms IT investment and IS implementation. IS implementation theory emphasises the role of the individual for innovation adoption and diffusion. Iansiti and Richards (2006) highlight the nature of IT innovation systems or IT ecosystems. This study provides a modified scheme representing the IT ecosystem at a more general level (see Section 2.3.5).	the researcher to examine a critical component of and IT innovation system. Reflecting on the case study findings and the dynamic model of IT innovation generated from the case studies the complex and systemic nature of IT innovation become evident. The same concept is also pervasive within innovation theory and it is recommended that the various approaches described under the systems of innovation literature be reviewed to determine their suitability in the context of any future IT innovation research. Although less prevalent in systems of innovation research, the functional approach may be particularly relevant for the study of IT innovation due to the organisational spanning nature of IT innovation. Guidance around innovation data collection would have the researcher focus on the organisation or firm as unit of analysis. This is inherently useful for marking comparison across firms in an economy or market. Whilst this study focused on organisational approaches, data collection and analysis was essentially following the innovation (in several cases) across organisations. Thus researchers should not overlook the utility of using the innovation itself as the unit of analysis (object approach). Further recommendations relating to the actors and agents involved in IT innovation, based on experience with the case studies of IT innovation practice include: • Looking beyond the boundary of the firm and toward the IT ecosystem as a whole to explain who gets involved with IT innovation (see Section 2.3.5). • Being sensitive to the possibility that actors and agents can perform multiple roles at the same time or at different stages of the innovation lifecycle. • Understanding that individuals can provide rich historical accounts of IT innovation than cannot be easily obtained through surveys and macro-economic measurements. • Consider the utility of King et al. (1994) institutional interventional model in describing institutional interventions.

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
Sources of knowledge for IT innovation		
	The innovation literature emphasises the influential nature of interactive working relationships between innovation stakeholders, suppliers and customers (OECD/Eurostat 2005). Through innovation processes, new and existing knowledge is routinely incorporated into products, processes and services (Popadiuk & Choo 2006). Knowledge is often combined with technology to create innovations either as new knowledge and technology, new uses or combinations of existing knowledge and technology. Knowledge can also be embodied in machinery or equipment. Technologies themselves are essentially 'the embodied knowledge of a productive process' (Baetjer 1997). The dynamic model of IT innovation generated from the case studies of IT innovation practice emphasise that IT innovation is part asset exploitation and development and part knowledge exploitation and development. The model defines three types of domain knowledge that is relevant to IT innovation – IT knowledge, business knowledge and area of application knowledge (see Section 6.4.6 for a concise definition of each knowledge type). The knowledge of how to design, develop, assemble and deploy specific information technologies (IT knowledge) is understandingly prevalent in IT innovation observed in the case studies. However the knowledge was not entirely technical/engineering-oriented knowledge. Knowledge of requirements analysis and project management were seen as influential in many cases. The mechanism of merging domain knowledge from innovation stakeholders and developers was primarily concerned with translating area of application knowledge in the form of requirements so it can be combined with IT knowledge to produce new or modified IT assets and capabilities. This type of knowledge management is well supported in the IT/IS literature (Newman & Robey 1992). The likelihood of IT/IS implementation success has been shown to increases with the quality of this type of (designer-user)	Whilst the sources of knowledge for innovation are many and varied, it was possible to consolidate the different sources of IT innovation knowledge into three domains – IT knowledge, business knowledge and area of application knowledge. It is recommended that researchers can use these domains as a starting point for further investigation. Delving beyond the three domains researchers should also investigate: • Any additional knowledge held within human capital across organisations and stakeholders involved with innovation i.e. developers, customers/users, suppliers. • Knowledge embodied in assets, acquired as capital equipment and machinery or already embodied in IT assets. • Knowledge relating to complementary and coordinating soft-skills, that in themselves are focused on coordinating knowledge management and innovation activity e.g. project management, business analysis, etc.

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	interaction (Kwon & Zmud 1987). Wang and Ramiller (2009) also highlight the form and diversity to which the merging of domain knowledge can occur within an innovation community emphasising the role of acquiring new, or modifying and reinforcing existing IT knowledge, through community interaction.	
The role of firm resources in IT innovation		
	The assets and capabilities (resources) controlled by an organisation enable them to improve efficiency and effectiveness thorough innovation. Amit and Schoemaker (1993) distinguish between assets, the tangible and intangible inputs that can be used in the organisations production process, and capabilities, the ability to deploy those assets for productive use. This resource-based view of the firm (Barney 1991) has been utilised within the IT/IS literature to argue that IT resources can be utilised to generate competitive advantage, particularly when used in conjunction with other, complementary resources (Clemons & Row 1991; Powell & Dent-Micallef 1997; Wade & Hulland 2004) Interaction between IT resources and other organisational resources has been shown to be highly significant and one of the most beneficial outcomes of IT investment (Brynjolfsson & Hitt 1998). The economics and IT/IS literature agree that IT demonstrates most if not all the characteristics of a general-purpose technology (GPT). Bresnahan and Trajtenberg (1995) argue that GPTs facilitate 'innovation complementarities'. Whilst this argument was made in relation to the downstream sectorial impacts of technology diffusion throughout the economy, innovation complementarities have also been shown to exist at or within the organisational context. Innovation complementarities have been shown to vary considerably from organisations to organisation and appear influenced by the configuration and alignment of unique factors within the organisational context (also know as firm-effects). Teece, Pisano and Shuen (1997) emphasises the importance of the firm's ability to develop and reconfigure resources in rapidly changing competitive	The notion of innovation complementarities taken from the literature and the role of resources discussed within the findings of this study suggest that that IT innovation outcomes are contingent upon the availability and capacity to exploit complementary resources. Conceivably the "firm effects" phenomena is linked to how an organisation conducts IT innovation; how it makes IT innovation decisions; and how it combines domain knowledge with the portfolio of assets and capabilities the firm has at its disposal to generate new assets and capabilities through a process of diffusion and feedback. Researchers should explore the role of IT resources in IT innovation activity and their interaction with other firm resources. Understanding the unique alignment and combination of assets and capabilities may yield important understandings about the success and benefits of IT innovation. The knowledge of productive processes is typically embedded in IT assets and capabilities. Either developed or improved internally or imported via external acquisition of IT capital and equipment. Continuous incremental IT innovation also exploits the flexibility of IT assets to be modified and improved. The capacity for IT assets to be combined with other firm resources in a dynamic fashion was a key finding integrated into the dynamic model IT innovation derived from the case studies. Experience from this research demonstrated that IT assets can be modified and deployed for completely different and unexpected purposes than may have originally intended. The following recommendations are provided to researchers in relation to the role of firm resources: • Explore and establish what assets and capabilities are involved

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	environments known as dynamic capabilities. Wade and Hulland (2004) argue that IT resources share many of the attributes associated with dynamic capabilities. Bharadwaj (2000) presents a modified scheme of information technology resources – information technology infrastructure; human information technology resources; and information technology enabled intangibles (customer orientation, knowledge assets, synergy across business functions). The dynamic model of IT innovation generated by the case studies of IT innovation practice describes a continuous and interactive resource utilisation, improvement and creation mechanism. It reveals interaction and development around three common types of organisational assets – products and services, IT assets, and data; It also reveals three types of capabilities – IT capabilities, information management capabilities and business capabilities, where capabilities are distinguished from assets as being resources with the ability or capacity to coordinate other resources for IT innovation activity. Furthermore, as outlined in previous section of this framework, IT resources can be both an input to and an output of IT innovation activity: • IT resources can be used as an input for IT innovation activity, either acquired as capital goods or operational services, or employed from the existing pool of IT resource; or • IT resources can become the object or outcome of IT innovation. The innovator develops, modifies or assembles (combines) various IT resources to produce new IT resources that are the primary outcome if IT innovation. The two roles are not exclusive and IT innovation where IT is the output of IT innovation activity is rare without an IT resource input[6]. Similarly, IT	with IT innovation and what knowledge is being embedded in any newly created, acquired or existing IT assets and capabilities. • Be sensitive to the capacity for IT assets to be combined with other firm resources in a dynamic fashion. • Because of the continuous incremental nature of IT innovation, follow the development and use of IT assets and capabilities through the life-cycle of an IT innovation.

[6] One exception may be using IT knowledge to put an IT capability into practice.

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	resources can be used to coordinate and facilitate outcomes that do not have IT resources as a significant output.	
The outcomes and benefits of IT innovation		
	The innovation literature demonstrates that most organisations benefit as a result of innovation. These benefits include improved customer service, increased revenue, gaining a competitive edge or achieving a reduction in costs (ABS 2014). Innovation theory often focuses on economics based approaches for measuring and understanding innovation outcomes. West (2009) argues that innovation can be viewed as an increase the quality of economic activity, where improvements in quality indirectly lead to a greater benefits and/or the avoidance of cost associated with specific economic activities. Whilst this research did not set out to measure the benefits or outcomes of IT innovation, the utility of higher-level generalised measurements of innovation outcomes is a conceivably useful method of dealing with the heterogeneity of benefits where comparison across organisations and innovations is required and feasible. Within the IT/IS literature there is a substantial body of knowledge relating to the organisational value of IT investments. Though not explicitly stated as such, this knowledge also provides important understandings of the outcomes and benefits obtained from IT innovation. Kohli and Grover (2008) provide a useful synopsis this literature arguing that the value of IT investment is both real (financial) and perceived, and that that value is – created in conjunction with complementary resources; manifested in many ways and at different levels; capable of creating competitive advantage (with some limitations); latent and often not immediate, lags behind the initial investment for some time; and ultimately difficult to measure. Observations from the case studies associated with this research largely support the IT/IS literature in relation to the organisational value of IT and place it in the context of IT innovation practice. Notable characteristics relating to the outcomes and benefits of IT innovation taken from the	Measuring the intangible outcomes benefits associated with IT innovation represents a significant challenge. Reflections from the model of dynamic IT innovation, the IT/IS literature and the innovation research literature suggest that researchers should explore the outcomes and benefits of IT innovation in the context of: • Different levels of benefit realisation individual, group organisational, etc. that apply to the research context. • Different increments and stages of the innovation's lifecycle. • Related and interacting IT assets, capabilities and firm resources. Researchers should also accommodate for latency and the continuous nature of IT innovation by looking at IT innovation over extended time periods. Where comparisons are required across sectors and industries it is recommended that researchers attempt to assess the high level economic impacts in terms of increased revenue reduced costs, improved quality and improved competitiveness. Guidance for successfully attempting this provided in the Oslo Manual (OECD/Eurostat 2005) and the experience of subsequent innovation studies conducted throughout OECD countries.

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	dynamic model of IT innovation are – • The heterogeneity of benefits. • Outcomes are uncertain and sometimes unexpected. • Benefits often exceed expectations, but sometimes take longer to emerge than anticipated. • IT innovation can be an object of investment or an agent of change. The case study data also suggest that IT innovation benefits are not simply produced or manufactured, rather they emerge from extended periods of IT innovation decision making and activity. The benefits realised from IT innovation are also different in terms of their nature and timing. The differences are not only across cases, but also within cases. For a single case the benefits realised during one phase of innovation can be different in terms of the nature and timing to the next.	
<u>Influential Factors</u>		
	Factors influencing innovation are described differently within the two domains of innovation and information systems. They are undoubtedly abstracted at different levels, but both contribute to a broader understanding of IT innovation. *From the innovation literature:* Maidique and Zirger (1984) proposes there is no single magical factor governing innovation success or failure. However, Van der Panne, Van Beers and Kleinknecht (2003) argue that factors can be grouped into firm, project, product and market related factors. The foundational characteristics and dimensions of innovation are also important for understanding the influencing factors associated with innovation – pervasiveness across many sectors makes for different factors (Hirsch-Kreinsen et al. 2003), uncertainty in outcomes (Rosenberg 1995), emergence within complex systems (Arthur 2009; Martin & Sunley 2007), access to knowledge and markets through collaborate networks (Carlsson & Jacobsson 1997), and historical path dependency (Arthur 1989; David 1986). *From the IT/IS literature:* User acceptance and ease of use have been	The range of factors influencing IT innovation are diverse. Both the IT/IS literature, innovation theory and experience gain from this study provide useful insight into factors that influence IT innovation at different levels. Understanding these factors and how organisations management them provides important insight into other characteristics and dimensions of IT innovation, specifically the decisions and processes that can be used maximise benefit realisation under certain conditions. The case study experience from this study suggests that organisations try to address many of the complex, emergent and path dependant factors through development and engineering methodologies, but that these methods vary with problems at hand. At a general level the following guidance is provided: • Understand that IT innovation activity in itself introduces new problems or opportunities through its lifecycle. As a consequence the factors influencing IT innovation change per a dynamic system. • User acceptance, adoption/use are highly influential for IT

Characteristic	Summary of the empirical position (theory and model)	Implications for conducting IT innovation research
	identified as important factors (Davis 1989). Delone and McLean (2002) propose that user satisfaction and intention to use an information systems is linked to information quality, system quality and service quality and that using the system will also realise certain benefits and these benefits will in turn feedback and influence user satisfaction and the further use of the system. *From dynamic model of IT innovation generated by the case studies:* Four factors are identified as being influential for IT innovation decisions – (1) the ability to identify and evaluate requirements for suitable IT innovation solutions; (2) problems and opportunities emerging from development (including the initial set of problems and opportunities); (3) responding to competitive pressures (market forces) and (4) the impact of changes in relation to IT resource dependencies (both constructive an unhelpful). Feedback in this model is the result of user acceptance and the impact of external technological changes upon current IT architectures.	innovation outcomes. Again acceptance is fluid and interactive process, it is not just a simple a yes/no decision at the end of a development phase. • Information systems quality is also important for IT innovation and user acceptance, but it is possible to identify and analyse information systems quality by investigating the how user/stakeholder requirements are met during development and testing. • Be sensitive to changes in IT platforms either at a technological, architectural or market level, particularly where there are technological path dependencies in play. Understanding IT architecture associated with specific IT innovations will assist in understanding the factors at play in this instance.

6.6 Synthesis of Findings

This research identifies a number of problems within the IT/IS literature relating to understandings of IT innovation. It also reviews the current definitions and understandings of innovation found within the innovation literature, with a view that innovation theory could be utilised to provide guidance for extending understandings of IT innovation.

In order to address the research problems and opportunities identified in literature review, two research questions were formulated:

- Research Question 1 – How and why do firms innovate with IT?
- Research Question 2 – How can organisational approaches and experiences in IT innovation be analysed?

Six high-level objectives were also established to fulfil the purpose of this thesis and answer the research questions:

(1) Source or provide a contemporary definition of IT innovation.
(2) Determine why organisations choose to innovate with information technology and how stakeholders make the decision to innovate.
(3) Discover the key activities associated with IT innovation along with who gets involved.
(4) Investigate the consequences and outcomes of IT innovation activity and how benefits are obtained.
(5) Determine the suitability of innovation theory as framework for analysing IT innovation and for guiding further research into IT innovation.
(6) Beyond existing understandings of IT innovation, identify any additional factors that are important for IT innovation and explore how they influence innovation activity and/or organisational outcomes.

6.6.1 How and why do firms innovate with IT?

This research question and the related objectives were initial addressed thorough the theoretical framework and the development of the heuristic model in Section 2.5. The heuristic model was then extended by the findings of the multi-case analysis of IT innovation practice (Section 6.2) and empirically grounded in the dynamic model of IT innovation described in Section 6.3.

6.6.1.1 Defining IT innovation

To address the question of how and why firms innovate with IT is necessary to provide a revised contemporary definition of what IT innovation is and represents. This research does not dismiss previous definitions of IT innovation provided within the literature, rather it reflects on the dynamic and evolving nature of IT innovation. The findings of this research argue that IT innovation should be viewed as a complex system working around IT artefacts and social structures, and that its definition is evolving with the technological phenomena that underpin it. IT innovation is also being shaped by the contexts to which it is being deployed. This study suggests that IT innovation is both an object of investment and agent of change. The following concise definition is provided from the findings of this research, accepting it will change with future research:

> *IT Innovation is complex system of interacting processes, agents, and artefacts, where information technology is the object of investment or an agent for change that can be used to solve information handling problems, or exploit opportunities that arise from the development or use of information technology.*

6.6.1.2 The Drivers of IT innovation

The reasons why organisations choose to innovate with information technology and how stakeholders make the decision to innovate are important for understanding the behaviours and consequences of IT innovation. Decision-making associated with IT innovation is predominately influenced by either a motivation to solve problems associated with the collection, processing, storage and distribution of information; or a desire to exploit favourable or advantageous conditions created by developing new or enhancing existing information technology solutions.

However, findings from this research also suggest that decision-making is frequently impacted by a number of factors. These factors include the capacity to identify and/or meaningfully evaluate the requirements for suitable IT solutions (new or existing); the ability to respond appropriately to emergence arising variously from: (1) New problems and/or opportunities during development (2) Competitive pressures (3) Dependencies associated with technological advancements of co-dependent and complementary IT assets and/or human capabilities utilised in IT innovation.

6.6.1.3 IT innovation processes

A major finding of this research is that IT innovation appears to emerge from diverse sets of inter-relationships within and between individual and organisational decisions, activities and behaviours relating to information technology. This research also found that IT innovation is intimately associated with the impact on organisational practices arising variously from the development and improvement of IT assets and capabilities. Though not causally linked to these practices, rather relying on the capacity of agents and actors to leverage domain knowledge and IT resources generated through these practices to achieve positive change.

The dynamic model of IT innovation associated with this multi-case study of IT innovation practice constitutes part of the findings of this research. This model proposes that IT innovation occurs on two integrative levels – a macro and micro level.

At the macro-level IT innovation was found to proceed incrementally with IT resources being developed and continuously integrated, cycling through phases of IT innovation decision-making, IT innovation activity and IT innovation outcomes. The continuation of these cycles always being contingent on individual and organisational knowledge of the impact and benefit of these processes to that point in time. At the micro-level, innovation processes were found to involve three practices or mechanisms – the merging of domain knowledge; creating, improving and utilising firm resources; and the testing and feedback of IT innovation outcomes to power the next increment of IT innovation. These practices were also found to be interacting with various stakeholders/agents, sources of knowledge and firm resources.

Within the model stakeholders or agents were found to be operating within various social structures throughout the IT innovation process. The role and importance of specific agents were found to change through various increments or cycles of IT innovation. Organisational boundaries were often found to be highly permeable with IT innovation activity spaning multiple organisations. This research also found that organisations operating within the IT sector approached these boundaries spanning relationships differently to those operating outside of the IT sector. IT producers were seen often taking advantage of industry networks as source of knowledge and market access for IT innovation; where IT users were often seen to partner with external developers or suppliers to source domain knowledge relating to IT engineering, development.

Firm resources were found to be important for IT innovation processes. The continuous and interactive resource utilisation, improvement and creation practices were found to involve the development of three common types of organisational assets – products and services, IT assets, and data. This practice also involved three types of organisational capabilities – IT capabilities, information management capabilities and business capabilities. IT resources in particular were found to be both an input to and an output of IT innovation. IT resources were used as an input for IT innovation processes, either acquired as capital goods or operational services, or employed from the existing pool of IT resource. IT resources were also the object or outcome of IT innovation as the innovator develops, modifies or assembles (combines) various IT resources to produce new IT resources that are the primary outcome if IT innovation. The two roles were not found to be exclusive, with input and output driven IT innovation activity being present in single cases of IT innovation.

This research emphasises that IT innovation is part firm asset exploitation and development and part knowledge exploitation and development. Three types of domain knowledge were identified as relevant to IT innovation – IT knowledge, business knowledge and area of application knowledge. Domain knowledge was distinguished from internal firm resources due to the nature of control often being vested within external organisations, social structures or technologies. The practice of merging domain knowledge from innovation stakeholders and developers was primarily concerned with translating area of application knowledge in the form of requirements so it can be combined with IT knowledge to produce new or modified IT assets and capabilities.

6.6.1.4 Consequences and outcomes of IT innovation

IT innovation is a complex, dynamic and emergent phenomenon. Findings drawn from the dynamic model of IT innovation associated with this multi-case study of IT innovation practice suggest that:

- The benefits associated with IT innovation varied considerably from context to context. Some innovators achieved large-scale economic benefits associated with global diffusion of their innovation, where other cases achieved significant change confined to the organisational context for which it was developed.
- IT innovation benefits are not simply produced or manufactured, rather they emerge from extended periods of IT innovation decision making and activity. The benefits realised from IT innovation are also different in terms of their nature and timing. For a given IT innovation the benefits realised during one phase of IT innovation can be different in terms of the nature and timing to the next.
- IT innovation outcomes often exceeded the expectations or objectives originally set for the IT innovation. In some instances extended benefits were achieved through a process of continued improvement during the life cycle of the IT innovation. In other instances extended benefits were achieved due to unanticipated effects of the innovation when placed into operations or use. Innovation outcomes where also shown to span organisational boundaries. The realisation of direct benefits (non-externalities) to collaborators appeared common in more than half of the cases investigated.
- The emergent properties of IT innovation yielded outcomes that could not be anticipated or predicted. For as many benefits that were planned and part of the innovation objectives there were as many unexpected and unplanned benefits obtained. Evidence was observed in case study data of instances where unanticipated outcomes became the main focus of IT innovation moving forward through its life cycle.

- IT innovation is both an object of organisational investment and an agent of organisational change in a manner that tends to be non-linear, organic and/or unpredictable. As an object of organisational investment the primary benefit was that the investment in IT assets and capabilities that could then be either commercialised as new products and services or employed to generate improvements in other firm resources. As an agent of organisational change IT assets and capabilities yield benefits in terms of the utility they provided for the way other firm resources performed or could be utilised by the innovating organisation.

Uncertainty and emergence were also found to be inherent properties of benefits realisation with implications for IT innovation. Uncertainty meant that stakeholders had difficulties predicting or forecasting the outcome of IT innovation activity i.e. uncertainty about the technological solution or approach, and uncertainty about the quality or fitness for purpose of the outputs of IT innovation activity. These uncertainties then appear to influence the type of IT innovation activities and approaches to problem solving. Emergence meant that IT innovation outcomes emerged from a process of interaction between innovation stakeholders and developers, using domain knowledge and firm resources to produce IT innovations. Often IT innovation decisions and IT innovation activity were seen to be undertaken with specific objectives in mind. Where those objectives were met, IT innovation outcomes were predictable, albeit something novel and new emerged. In some instances IT innovation outcomes were qualitatively different than expected, and outcomes exceeded expectations or realised unanticipated results.

There were also a number of factors that appeared to influence IT innovation outcomes for the cases under study:

- Industry level advances in information technology operating platforms; systems and development techniques had a significant impact on IT innovation outcomes. For some innovators these advances were a key enabler for success, opening up new opportunities or new methods of solving problems. For others they represented a challenge where change was required to maintain existing systems dependencies or to remain competitive.

- Innovator interaction with industry networks was also found to facilitate customer access and diffusion of IT innovations through related and complementary markets, positively influencing IT innovation outcomes in instances involving IT producer organisations.
- Intellectual property rights also presented challenges for few innovators, although for the cases influenced by this issue they were not addresses or reviewed until considerable IT innovation activity had progressed.

6.6.2 How can organisational approaches and experiences in IT innovation be analysed?

The second research question and related objectives were addressed by the knowledge framework described in Section 6.5. The knowledge framework was generated from re-examining the existing IT/IS and innovation literature in the context of insights gained from the development of the dynamic model of IT innovation relating to the nine case studies of IT innovation practice (Section 6.3).

The development of a heuristic model based on innovation theory (Section 2.5), the collection of data relating to IT innovation practice, the construction of the associated case study analysis (Chapters 4 and 5), and the development of the dynamic model for IT innovation (Section 6.3) demonstrate the value and practicability of utilising innovation theory as a guide for investigating IT innovation phenomena.

The knowledge framework presented as part of this thesis moves beyond the limitations of diffusion and adoption perspectives previously employed by Kwon and Zmud (1987), Swanson (1994) and Mustonen-Ollila and Lyytinen (2003), and highlights the continuous and sustaining nature of IT innovation to encapsulate a knowledge framework that supports a dynamic model of IT innovation (Lyytinen & Rose 2003). This knowledge framework provides the following high-level recommendations for investigating and analysing IT innovation phenomena.

6.6.2.1 Defining IT innovation

The contemporary definition provided from the findings of this research provides an update on those developed in previous research, however it is expected to change with the evolving dynamic nature of IT innovation itself. The framework recommends that IT innovation be viewed as complex system where IT innovation both an object of investment and an agent for change.

6.6.2.2 Innovation typologies

The framework provides an updated typology for IT innovation that extends the work of Swanson (1994) and Carlo, Lyytinen and Rose (2011) with a scheme that classifies IT innovation as either an IT base innovation, an IT related process innovation, or an IT related product and service innovation.

6.6.2.3 Drivers of IT innovation

The framework recommends researchers be aware of the high level objectives identified for IT innovation outlined in the case study findings. It also highlights the reasons and objectives for IT innovation can change, because they are part of a cycle of incremental feedback and response on a micro scale, and in the longer term part of lifecycle of innovation decision making on a macro scale. It recommends researchers be aware that there are different types, levels and stages of objectives that can be accessed by utilising the heuristic model used in this research. This heuristic model recommends that data collection and analysis be sensitive to the antecedents, behaviours and consequences of IT innovation in the form of IT innovation decisions, IT innovation activity and IT innovation outcomes respectively.

With regards to IT innovation processes, the framework identifies a critical difference between IT/IS theory and innovation theory in terms of how IT innovation processes are conceptualised. The framework suggests that procedurally driven methods and processes have, and still remain an important institution for IT/IS development practice and that the best way to resolve this conceptual difference is to integrate those understandings of IT innovation processes into the an innovation systems based approach, possibly the functional approach advocated by Carlsson and Jacobsson (1997). The framework also suggests that researchers look closely at the three development mechanisms drawn from case study model, to see if they remain relevant and useful for describing IT innovation activity.

6.6.2.4 IT innovation stakeholders

The framework suggests that identifying who is involved in IT innovation allows the researcher to identify potential sources of information relating to IT innovation decisions, activity and outcomes. At a broader level it allows the researcher to examine a critical component of and IT innovation system. The framework also recommends that researchers may find utility in focusing on the innovation (object approach) as the level of analysis for investigation of IT innovation phenomena as opposed to the more accepted firm level (subject approach) advocated for innovation studies by the Oslo Manual (OECD/Eurostat 2005). This justified in terms of the experience with the case studies of IT innovation practice that found IT innovation involve permeable organisational boundaries and stakeholders operating across a diverse IT ecosystem for any single IT innovation.

6.6.2.5 Sources of knowledge for IT innovation

The framework suggests that the three high level sources of knowledge described in findings, and model associated with the case studies of IT innovation practice, would provide a useful starting point for future investigations. The framework also recommends on the basis of other empirical work, researchers should also investigate knowledge held within human capital across organisations and stakeholders involved with innovation; knowledge embodied in assets, acquired as capital equipment and machinery or already embodied in IT assets; and knowledge relating to complementary and coordinating soft-skills, that in themselves are focused on coordinating knowledge management and innovation activity.

6.6.2.6 The role of firm resources in IT innovation

Following extensive empirical support beyond the case study findings and model, the knowledge framework proposes that if IT innovation outcomes are contingent upon the availability and capacity to exploit complementary resources, then conceivably this phenomena could be linked to how an organisation undertakes IT innovation. The framework recommends that researchers should explore the role of IT resources in IT innovation activity and their interaction with other firm resources. Understanding the unique alignment and combination of assets and capabilities may yield important understandings about the success and benefits of IT innovation. The framework also emphasises the continuous incremental and uncertain nature of IT innovation and stressed the importance of following the development and use of IT assets and capabilities through the life-cycle of an IT innovation, because the nature and use of IT assets and capabilities were demonstrated to change in the case study experiences.

6.6.2.7 The outcomes and benefits of IT innovation

Based on reflections from the model of dynamic IT innovation and other empirical studies, the knowledge framework recommends that researchers explore the outcomes and benefits of IT innovation in the context of different levels of benefit realisation, such as individual, group organisational; different increments and stages of the innovation's lifecycle; and related and interacting IT assets, capabilities, and firm resources. The framework also recommends that researchers should also accommodate for latency and the continuous nature of IT innovation by looking at IT innovation over extended time periods.

6.6.2.8 Influential factors for IT innovation

The framework concludes to address the final research objectives and seeks to identify any additional factors that are important for IT innovation and explore how they influence innovation activity and/or organisational outcomes. Overall the framework suggests that based on the case study findings, organisations will try to address many of the complex, emergent and path dependant factors associated with IT innovation through development and engineering methodologies, but that these methods will vary with the problem at hand. As such the following general guidance is provided for researchers. Understand that IT innovation activity in itself introduces new problems or opportunities through its lifecycle. As a consequence the factors influencing IT innovation change per a dynamic system. User acceptance, adoption/use are highly influential for IT innovation outcomes. Again acceptance is fluid and interactive process, it is not just a simple a yes/no decision at the end of a development phase. Information systems quality is also important for IT innovation and user acceptance, but it is possible to identify and analyse information systems quality by investigating the how user/stakeholder requirements are met during development and testing. Organisations need to be sensitive to changes in IT platforms either at a technological, architectural, or market level, particularly where there are technological path dependencies in play. Understanding IT architecture associated with specific IT innovations will assist in understanding the factors at play in this instance.

6.7 Chapter summary and reflection

This chapter provides an interpretation and discussion of the multi-case study analysis of IT innovation practice through three stages of discussion and interpretation.

This chapter begins with a review and discussion of the preliminary findings from the case studies in Chapters 4 and 5, reflecting and consolidating the themes to provide a starting point for further interpretation. This initial discussion is utilised to generate a multi-level model of dynamic IT innovation relating to the case studies.

The dynamic model and findings were again reviewed, but this time in the context of the IT/IS and innovation literature. Typically the theoretical strengths and weakness were identified for specific IT innovation characteristics, and then evaluated and discussed in the context of the model. Where similarities, differences and gaps emerged within existing theory they were emphasised and discussed. This discussion was then used as the basis for presenting a knowledge framework that could provide guidance for researchers and partitioners involved with investigation or analysis of IT innovation phenomena. Many similarities were found across the different IT innovation characteristics. Often theory within one domain was seen to be complementary in terms of decrying or explaining the IT innovation phenomena. Theory taken from the innovation domain was often abstracted at a higher level than that within the IT/IS domain. Several contradictory or ambiguous areas of theory were also notable. The utility of and accuracy of IT innovation typologies was discussed and debated, and propensity for procedural and linear models to be utilised within IT/IS theory and the model remained an outstanding issue.

The knowledge framework was generated using understandings of current theory and empirical insights and experience gained from the dynamic model of IT innovation relating to the case studies. It provides a contemporary definition for IT innovation that is expected to change with the continued evolution of IT innovation. It also provides an updated typology of IT innovations and identifies the drivers, processes, stakeholders, sources of knowledge, role of firm resources, and the outcomes and benefits associated with IT innovation. The framework concludes by identifying several influential factors associated with IT innovation. The knowledge framework moves beyond the limitations of diffusion and adoption perspectives previously employed by Kwon and Zmud (1987), Swanson (1994) and Mustonen-Ollila and Lyytinen (2003), and highlights the continuous and sustaining nature of IT innovation to encapsulate a knowledge framework that supports a dynamic model of IT innovation (Lyytinen & Rose 2003).

This chapter concludes with a synthesis of the findings aimed at addressing the research questions and objectives. It consolidates findings associated with the dynamic model of IT innovation grounded in the case studies and insights provided by the knowledge framework that comprises of theory transferred from the model, current IT/IS theory and contemporary innovation theory.

The next chapter provides a conclusion of this study. It provides a summary of the findings associated with this research and the contribution it makes at the substantive, methodological and theoretical level. It also discusses the limitations and recommendations for future research.

7 CONCLUSIONS AND FUTURE WORK

7.1 Introduction

The purpose of this thesis is to investigate IT innovation practice amongst IT users and producer organisations in order to provide a substantive, theoretical and methodological contribution to understanding IT innovation. This chapter provides a summary of the key findings of this research in conjunction with a discussion of its contribution to research made at a substantive, theoretical and methodological level. This chapter also discusses the limitations associated with this study, and provides recommendations for organisations engaging in IT innovation and for researchers investigating IT innovation phenomena. This chapter concludes by providing suggestions for future IT innovation research.

The chapter is structured in the following sections:

- Section 7.2 summarises the key findings associated with this research.
- Section 7.3 discusses the research contributions made at a substantive, theoretical and methodological level.
- Section 7.4 discusses the limitations associated with this study and its research approach.
- Section 7.5 provides recommendations practitioners and researchers engaging in IT innovation.
- Section 7.6 suggests several areas for IT innovation future research.
- Section 7.7 provides a final reflection and conclusion for this thesis

7.2 Summary of findings

This thesis has presented a multi-case study investigation of organisational approaches and experiences in IT innovation. Building on an empirically grounded dynamic model of IT innovation based on nine case studies of IT innovation practice (Section 6.3), this research generated a knowledge framework that aims to enhance IT innovation theory and practice (Section 6.5).

This research seeks to address two research questions relating to understandings of IT innovation – (1) how and why do firms innovate with IT, and (2) how can organisational approaches and experiences in IT innovation be analysed. A detailed syntheses of the research findings linked to the research questions is provided in Section 6.6. A summary of the key findings is provided as follows:

(1) IT innovation emerges from diverse sets of inter-relationships within and between individual and organisational decisions, activities, and behaviours relating to information technology. It is intimately associated with the impact on organisational practices arising variously from the development and improvement of IT assets and capabilities. However, it is not causally linked to these practices relying rather on the capacity to leverage the knowledge and IT resources generated through these practices to achieve positive change.

(2) IT innovation is a complex, dynamic, and emergent phenomenon. Its outcomes are subject to uncertainty, often being unanticipated and/or exceeding original expectations. This fluidity relates directly to how decisions, activities and behaviours iteratively evolve during the innovation process and how this influences the realisation of benefits. IT innovation is both an object of organisational investment and an agent of organisational change in a manner that tends to be non-linear, organic and/or unpredictable.

(3) IT innovation occurs incrementally with the technology artefact being developed and continuously integrated, cycling through phases of IT innovation decision-making, IT innovation activity, and IT innovation outcomes. The continuation of these cycles always being contingent on individual and organisational knowledge of the impact and benefit of these processes to that point in time.

(4) Decision-making in IT innovation is predominately influenced by either a motivation to solve problems associated with the collection, processing, storage and distribution of information, or a desire to exploit favourable or advantageous conditions created by developing new or enhancing existing information technology solutions. However, this decision-making is frequently impacted on by difficulties associated with a number of factors. These factors include the capacity to identify and/or meaningfully evaluate the requirements for suitable IT solutions (new or existing); the ability to respond appropriately to emergence arising variously from: (i) New problems and/or opportunities during development (ii) Competitive pressures (iii) Dependencies associated with technological advancements of co-dependent and complementary IT assets and/or human capabilities utilised in IT innovation.

(5) IT innovation appears to vary in subtle ways when comparing IT producers and IT users. IT producers often appear to take advantage of industry networks as source of knowledge and market access for IT innovation. IT users often partner with external developers or suppliers to source domain knowledge relating to IT engineering, development and implementation subsequently deployed in IT innovation.

(6) This research also generates a knowledge framework for IT innovation (Section 6.5) using understandings of current IT/IS and innovation theory, along with empirical insights and experience gained from the dynamic model of IT innovation relating to the case studies. The knowledge framework provides definitional, theoretical, and investigational guidance for practitioners and researchers to explore future cases of IT innovation. The knowledge framework comprises of seven factors to provide the initial foundations for the future investigation of organisational approaches and experiences in IT innovation – the definition of IT innovation, IT innovation typologies, the reasons and objectives for IT innovation, the outcomes and benefits of IT innovation, how IT innovation happens, and factors of success associated with IT innovation. The knowledge framework also emphasises that data collection and analysis must be sensitive to the dynamic and emergent aspects of IT innovation, and needs to use tools and techniques contingent on the circumstances found in each case rather than on those features prescribed by theory. It also highlights the need for researchers to recognise the tendency for IT innovations to be approached simultaneously as both objects of investment and agents of change transforming organisational processes.

7.3 Contributions to theory and practice

At a substantive level this thesis presents an in-depth study of nine Australian organisations, their approaches and experiences with IT innovation. Organisational cases were purposefully selected to maximise the opportunity to explore variations in approach and experience. Variation was achieved by selecting cases of different types of innovation; different areas of application; and different organisational contexts, including organisations of different size, geographical scope and primary business activity. With respect to the primary business activity, four IT producer organisations and five IT user organisations were selected.

For the nine organisational case studies of IT innovation practice this this research presents a dynamic model of IT innovation (Section 6.3) that confirms the importance of mechanisms that combine domain knowledge with new and existing IT assets and capabilities to create platforms for continuous innovation. In particular, it acknowledges the role of requirements management and user feedback processes that can be used to improve the prospects of diffusion and derive extended and unanticipated benefits over longer time frames.

At a theoretical level this thesis initially presents a heuristic model (Section 2.5) drawn from the empirical guidance used in innovation studies to address problems relating to IT innovation found within the IT/IS literature, to allow researchers to explore and analyse IT innovation practice more effectively. Through the research process the heuristic model was reinvigorated and advanced through the development of a dynamic model of IT innovation relating to the case studies of IT innovation practice (Section 6.3), and again with the development the knowledge framework to guide further research of IT innovation phenomena (Section 6.5). It is anticipated that the heuristic model, the dynamic model of IT innovation and knowledge framework for IT innovation research combine to make a significant contribution to leveraging and grounding insights from innovation theory with the practices of engaging with IT innovation at the organisational level. This research also demonstrated how IT/IS theory and innovation theory could inform each other, and how both are still missing understandings of IT innovation.

The knowledge framework also emphasises the need for future research to be sensitive to the inherent dualism of technology (such that it is frequently approached as both and object and agent of change) in IT innovation to support identification of emergence and uncertainty in organisational settings.

At the methodological level this research initially demonstrates how innovation theory can be used to guide elements of data collection relating to IT innovation. The dynamic model of IT innovation generated from the case studies then illustrates how data collection and analysis can explore the activities and events associated with the design, development, and diffusion of IT innovations to reveal the continuous and incremental development processes; the role of IT assets and capabilities in IT innovation decisions, activities and outcomes over time; and the collaboration and interaction amongst stakeholders working on IT innovations within various diverse social and organisational settings.

This research also identifies issues defining and understanding IT innovation phenomena within the IT/IS literature and presents a modified knowledge framework (Section 6.5) that incorporates contemporary innovation theory in order to facilitate and guide research looking to explore IT innovation phenomena.

7.4 Limitations of the study

Inherent within the research methods used in this research are a number of strengths and weaknesses. It is important to reflect on the limitations of these methods and demonstrate how they have been addressed.

7.4.1 Scope of research

This thesis acknowledges that the model and framework have been generated from qualitative field techniques employed amongst a small number of organisational cases. However, this research was of an exploratory nature where the objective was to generate detailed insight into the IT innovation practices amongst a number of organisations in different contexts.

This research was not a longitudinal study, but nor was it a snapshot in time beyond interviews being conducted in single sessions. Central to the interview protocol and subsequent data collection, a detailed history was sort from each interview participant. The data resulting in a rich history of IT innovation practice extending several or more years.

There are two specific limitations associated with the scope of this research outlined below:

- Case selection – a small number of organisational cases were selected for the conduct of this research. Firm sizes ranged from small micro businesses (1-4 FTE) to larger SME style business (250+ FTE). Absent from the portfolio cases selected was the presence of a large company and in respect to the context of IT innovation, the lack of a globally significant IT company (Big IT).
- Single informants – all but two of the nine cases relied on a single key informant to reconstruct events associated with a specific case of IT innovation. The use of a single informant to recall and reconstruct events can result in systemic bias and random errors (Kumar, Stern & Anderson 1993). Whilst various tactics were employed to eliminate these issues (See Section 3.4), it is acknowledged that bias and errors in the accounts provided by key informants would potentially be present. Where it was practicable to utilise multiple informants at the case level they were utilised.

Looking to the future, it is to be hoped that the dynamic model of IT innovation and the knowledge framework for IT innovation will be tested in other IT innovation contexts, where further research findings would be contributed. It can be anticipated that with the increased use of "Big IT", social media, and increased consumer applications and services, that researchers will need to extend the model and framework to deal with this diversity in IT innovation. However, it is anticipated that this thesis has contributed insights that will prove useful for both theory and practice in IT innovation.

7.4.1.1 The impact of research scope

The scope of this research may also have influenced the case study design. This research was undertaken as a requirement for the fulfilment of a doctoral thesis; the amount of time and resources available was finite. With the range of data available to be collected being relatively large, the time to analyse and interpret the data potentially could be indefinite. Fortunately, the temporal boundaries of the research is predetermined and bound by the rules and guidelines set by the research institution overseeing this research.

7.5 Recommendations for practitioners and researchers engaging in IT innovation

This research proposes that IT innovation is complex emergent system rather than a simple output or process. It suggests that IT innovation can be both an object of investment and an agent of change.

For practitioners this research recommends that:

- Practitioners utilise IT development and implementation methods or processes that allow them to closely interact with the various agents and stakeholders that can provide to access to domain knowledge and assist in development of IT assets and capabilities. Whilst there is a range of standard processes and methodologies that can be employed by practitioners, this research suggests that their selection should be aligned with the problem or opportunity at hand, and that this may change through the life-cycle of an IT innovation.
- Practitioners should be careful about having short-term views or objectives associated with realising the benefits of IT innovation.
- Practitioners should understand how IT resource dependencies enable and impact other resources involved in IT innovation.
- For IT producers this research highlights the opportunity provided by third party IT platforms and their supporting ecosystems as sources of knowledge and market access for IT innovation.
- For IT users this research reveals the importance of interaction between users and developers to progress IT innovation. It also acknowledges the role of IT producers as an important source of IT domain knowledge for IT users.

For researchers this research recommends that:

- Innovation theory can provide significant insight and utility for understanding and analysing organisational approaches and experiences in IT innovation, and that this research can complement existing research with the IT/IS domain.
- IT innovation itself is evolving with the continuous development and diffusion of information technology, and as such will further change and evolve with future investigations.

- The knowledge framework presented as part of this thesis can be utilised for and extended by future research associated with IT innovation.

7.6 Recommendations for future research

This thesis has provided an exploratory study of organisational approaches and experiences in IT innovation. It develops a dynamic model of IT innovation grounded in the finding from nine cases of organisational IT innovation practice, and a knowledge framework that aims to assist future researchers to investigate IT innovation phenomena. It is envisaged that future work will expand upon this exploratory research to investigate in detail various components of this thesis, either further testing and advancement of the dynamic model associated with other cases of IT innovation practice and/or extending the knowledge framework to include updated characteristics, dimensions or important factors associated with IT innovation.

Future research may also include focus on various elements of the dynamic model of IT innovation, including but not limited to:

- How does the management approach, taken in relation to uncertainty, influence the speed and quantum of IT innovation outcomes? For example, do you get greater benefit from an entrepreneurial or a risk managed approach IT innovation (see Section 6.3.1.3).
- How do the different high level innovation objectives (solving a problem versus exploiting opportunities) influence or result in different IT innovation behaviours?
- When or where are agile development and continuous delivery (DevOps) better suited for the evolving IT innovation landscape?

These are just some of the potential areas for future research in this evolving but important research area. Despite the exploratory nature of this research it is anticipated that this thesis will make a valuable contribution as a base for future research associated with IT innovation.

7.7 Concluding reflections

The purpose of this thesis was to investigate IT innovation practice amongst organisations in order to provide a substantive, theoretical, and methodological contribution to the disciplines of information systems research and innovation theory.

This research initially developed a heuristic model based on contemporary innovation theory that is used to guide data collection and analysis for IT innovation. This model was then enhanced with the development of a dynamic model of IT innovation grounded in the findings of nine cases of organisational IT innovation practice. This model, and the existing IT/IS and innovation literature, are then integrated to generate a knowledge framework that aims to enhance IT innovation theory and practice.

Given the importance of innovation for economic growth and role information technology now plays in developing and shaping the economy, the researcher was surprised by lack of ongoing research linking innovation and IT development. The researcher hopes that elements of this thesis will be helpful for organisations, practitioners and researchers interested in or involved with IT innovation. This thesis aims to provide a foundation for future works in this important research area. It is hoped that this research will encourage other researchers to continue advancing the knowledge framework and understandings of IT innovation.

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APPENDICES

Appendix A – Example research information sheet

Research Information Sheet

Exploring the Role of Information Technology in Firm Innovation Activities and Outcomes.

Invitation

Your organisation is invited to participate in a research study which will explore the role of information technology in firm innovation activities and outcomes.

The study is being conducted by the Australian Innovation Research Centre as part of a PhD program undertaken by Justin Thurley under the supervision of Professor Jonathan West and Professor Keith Smith.

What is the purpose of this study?

The primary aim of this study is to review the use of information technology in the context of innovative projects undertaken by your business.

In 2007 the Australian Innovation Research Centre conducted a detailed company level survey (census) of innovation activity in Tasmania. One of the findings of this survey was that large number of innovative firms indicated that they were utilising information and communications technology (ICT) in their innovation activities.

Unfortunately the survey was not detailed enough to determine the extract role of information technology within the innovation process.

Hence study aims to gather a detailed analysis of how a Tasmanian business has utilised information technology for innovative business outcomes. This analysis will then be used to develop a more detailed survey of other innovative Tasmanian businesses.

What do we mean by "innovation"?

Innovation can be loosely defined as the act of introducing something new. However, for the purpose of this study we prefer a more specific definition used by the Organisation for Economic Co-operation and Development (OECD) which describes innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations".

Why have I been invited to participate in this study?

Your organisation has been invited to participate in this study because it is perceived to have invested in information technology as part of one or more innovative business outcomes.

What does this study involve?

This study involves the collection of data relating to information technology investment, use and management. It may also involve the collection of data pertaining to other assets and/or resources where relationships can be established with investment, use and management of information technology for an innovative outcome.

Data will be collected via interview, field notes and the review of documents and related artefacts.

Interviews would be undertaken with a range of employees on your premises at mutually agreed times and only with their formal signed consent. Interviews would not usually exceed an hour in duration, however on occasion the investigator may need to conduct more than one interview. Interviews would normally be recorded and transcribed into text for analysis.

Field notes are notes taken by the investigator which describe or connect the investigators observations and experiences during the data collection process.

Documents and other artefacts would normally be reviewed on site. Documents will not be copied or removed from your organisation without your expressed permission and where copies are made; a register of copied documents will be maintained and made accessible for your review at any time.

It is important that you understand that your organisations involvement in this study is voluntary. While we would be pleased to have you participate, we respect your right to decline. There will be no consequences to you if you decide not to participate, and this will not affect your treatment / service. If you decide to discontinue participation at any time, you may do so without providing an explanation.

What are the benefits of participating in this study?

Many business leaders, government policy makers and some economists believe that technological and organisational innovations are responsible for long run economic growth. Your participation in this study is expected to assist in our understanding of how information technology is used to generate innovative outcomes within organisations. These findings may have important policy implications for the way government and other organisations seek to fund programs involving information technology innovation and diffusion within industry.

As part of the study we will collect data about your organisations investment, management and use of information technologies. This information will provided back to you in a structured format which may be useful for developing strategies and tactics for dealing with future innovations. Furthermore, as a participant in the study you will also receive a copy of the overall findings linked to a more extensive survey of information technology use in Tasmanian businesses.

What are the risks associated with this study?

Participation in this study involves minimal risk to your organisation; however there is a risk that some data collected as part of the research process may be of a commercially sensitive and/or confidential nature.

For this purpose, "confidential information" shall be taken to mean information of or in the possession of the researchers that: (i) is by its nature confidential; (ii) you have designated as confidential; (iii) is inferred as being confidential; or (iv) we as researchers know or ought to know is confidential.

To mitigate this risk comprehensive privacy and confidentiality procedures will be put in place to ensure that:

a) all information will be treated in a confidential manner and that a register of copied documents and interview schedules be maintained at all times;

b) neither your organisation or any of its staff can be identified in any publication arising out of the research;

c) you will have the opportunity to review recorded data and stipulate that records not be included for publication, or otherwise be reported in a way that you prescribe; and

d) all data collected in relation to the study will be protected and stored in a secure environment at the University of Tasmania and destroyed when no longer required.

What if I have questions about this research?

If you would like to discuss any aspect of this study please feel free to contact Justin Thurley on (##) #### ####, who would be happy to discuss any aspect of the research with you.

This study has been approved by the Tasmanian Health and Medical Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study you should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote reference number H9949.

Thank you for taking the time to consider this study.

If you wish to take part in it, please sign the attached consent form.

This information sheet is for you to keep.

Appendix B – Example participant consent form

PARTICIPANT CONSENT FORM

Exploring the Role of Information Technology in Firm Innovation Activities and Outcomes.

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1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. Any questions that I have asked have been answered to my satisfaction.
4. I understand that that this study involves the collection of data via interviews and the review of documents and other related records; and that with my permission, interviews may be recorded and transcribed into text. I also understand that the data collection process may involve more than one session and that additional sessions will be scheduled at a mutually agreeable time.
5. I understand that my participation in this study involves minimal risk to me or my organisation, but that there is a risk that some data collected as part of the research process may be of a confidential nature.
6. I acknowledge that the procedures for handling privacy and confidentiality associated with this research have been fully explained to me and I understand that the researchers will maintain my identity confidential and that any information I supply to the researchers will be used only for the purposes of the research.
9. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish may request that any data I have supplied to date be withdrawn from the research.

Name of Participant Organisation:

Authorised Representative:

Signature: Date:

Statement by Investigator

☐ I have explained the project & the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project.

Name of Investigator:

Signature of Investigator: Date: